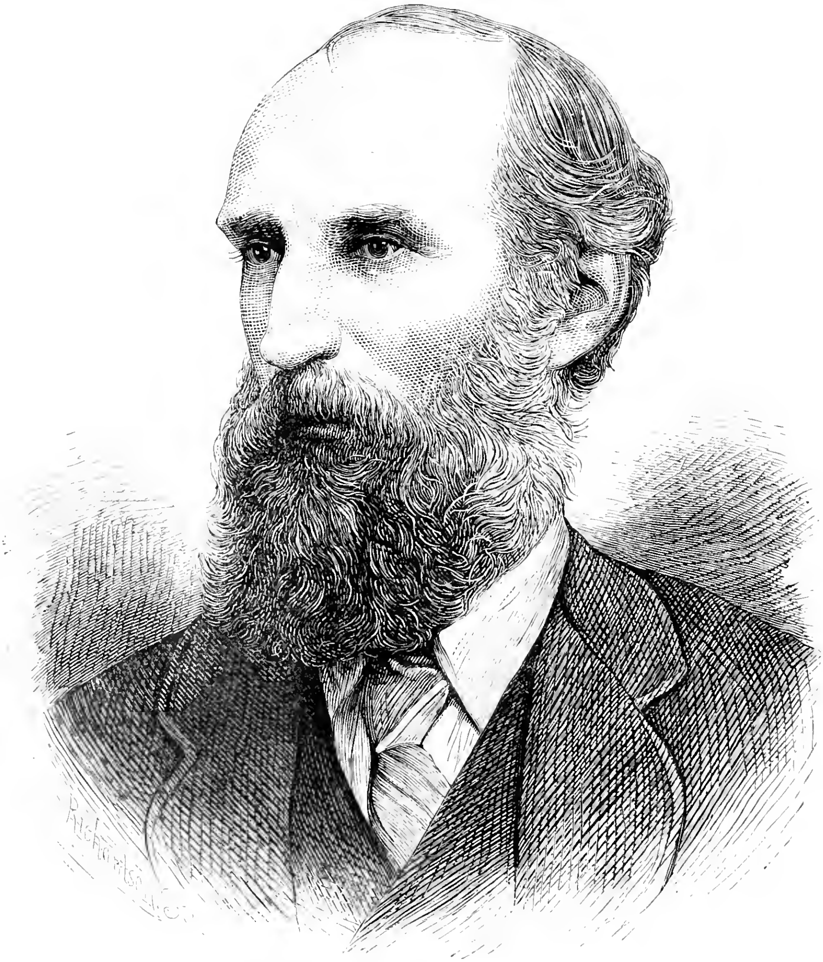


WILLIAM SPOTTISWOODE

THE

POPULAR SCIENCE

MONTHLY.

CONDUCTED BY E. L. AND W. J. YOUMANS.

VOL. XIV.

NOVEMBER, 1878, TO APRIL, 1879.

NEW YORK:
D. APPLETON AND COMPANY,
549 & 551 BROADWAY.
1879.

THE

POPULAR SCIENCE MONTHLY.

NOVEMBER, 1878.

THE CONTRAST OF COLORS.[1]

By Professor O. N. ROOD.

IN a previous chapter we have studied the changes which colored surfaces experience when viewed under various kinds of illumination, or when modified in appearance by the admixture of more or less white or colored light. The appearance which a colored surface presents to us can, however, be altered very materially, by a method which is quite different from any of those that have thus far been mentioned: we can actually change color to a considerable extent without at all meddling with it directly, it being for this purpose only necessary to alter the color which lies adjacent to it. The truth of this can be seen by a very simple experiment: If we cut out of a sheet of red paper two square pieces, about an inch in size, and then place one of them on

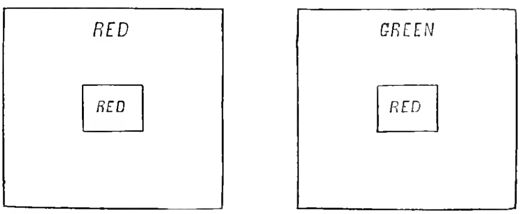


Fig. 1.—Sheets of Red and Green Paper with Red Squares.

a sheet of red, the other on a sheet of green paper, as indicated in Fig. 1, it will be found that the red square on the red paper will not appear nearly so brilliant and saturated in color as that placed on the green ground; hence the observer will be disposed to doubt whether the two

[1] From the advance-sheets of a work on "Chromatics, with Applications to Art and Industry."

squares are really identical in hue. By a somewhat analogous proceeding we can cause a surface which properly has no color of its own, which is really gray, to appear tinted red, blue, green, etc. These changes, and others of a like character, are produced by what is called contrast, and are partly due to actual effects generated in the eye itself, and partly to fluctuations in the judgment of the observer. The subject of contrast is so important that it will be worth while to make a somewhat careful examination of the laws which govern it, and it will be well for the reader to repeat some of the simple experiments described below. If we place a small piece of bright-green paper on a sheet of gray drawing-paper, in the manner indicated in Fig. 2, and then for several seconds attentively look at the small cross in the centre of the green slip, we shall find, on suddenly removing it, that in its place a faint image of a rose-red color makes its appearance (*see* Fig. 3). This

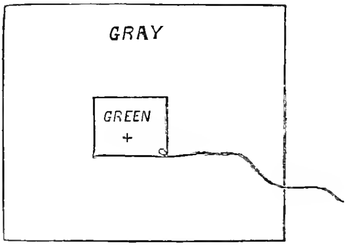


Fig. 2.—Gray Paper with Green Slip.

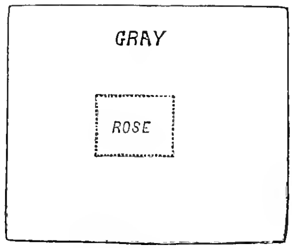


Fig. 3.—Gray Paper with Rose-colored Image.

red image presently vanishes, and the gray paper resumes its natural appearance. The rose-red ghost which is thus developed has a color which is complementary to that which called it into existence, and this will also be the case if we employ little squares of other colors : red will give rise to a greenish-blue image, blue to a yellow, violet to a greenish-yellow, etc., the color of the image being always complementary to that which gave rise to it. Upon this account these images are called *negative*, since as far as the color goes they are just the reverse of the images which are first presented to the eye of the observer. They are also often spoken of, in older treatises on optics, as "the accidental colors." It is quite easy to explain their production with the aid of the theory of Young and Helmholtz. Let us take as an example the experiment just described: According to our theory the green light from the little squares of paper, acting on the eye, fatigues to some extent the green nerves of the retina, the red and violet nerves meanwhile not being much affected. When the green paper is suddenly jerked away by the string, gray light is presented to the fatigued retina, and this gray light may be considered to consist, as far as we are concerned, of red, green, and violet light. The red and violet nerves, not being fatigued, respond powerfully to this stimulus ; the green nerves, however, answer this new call on them more feebly, and in consequence

we have presented to us, mainly, a mixture of the sensations red and violet, giving as a final result rose-red or purplish-red. The green nerves, of course, are not so fatigued that they do not act at all when the gray light is presented to them, but the only effect that their partial action has, is to render the rose-colored image somewhat pale or whitish in appearance. The fatigue of the optic nerve mentioned here does not differ essentially from that which it undergoes constantly even under the conditions of ordinary use, where the waste is constantly made good by the blood circulating in the retina, and by the little intervals of rest constantly occurring. In our experiment we have merely confined the fatigue to one set of nerves, instead of distributing it equally among the three sets.

The above experiments and explanation will enable us easily to comprehend the more complicated case, where, instead of placing our little green square on gray, we lay it on a sheet of colored paper. Instead, then, of gray, let us take yellow paper, placing the green square on it as before (*see* Fig. 4). On suddenly withdrawing the green square, we find it replaced by an orange-colored ghost (Fig. 5), which

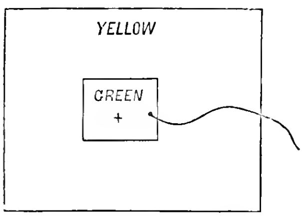


Fig. 4.—Yellow Ground with Green Slip.

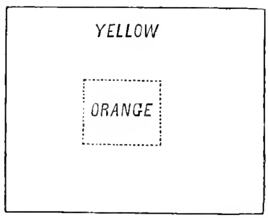


Fig. 5.—Yellow Ground wth Orange-colored Image.

we account for thus: As before, the green nerves are fatigued, the red and violet nerves remaining fresh; when the square is removed, yellow light is presented to the retina, and this yellow light, as explained in Chapter IX., tends to act on the red and green nerves equally, but the green nerves in the present case do not respond with full activity, hence the action is more confined to the red nerves, and, as explained in Chapter X., the resultant tint is necessarily orange, that is to say, we have a strong red sensation mingled with a weak green sensation, and the result is the sensation called orange. In this experiment the violet nerves do not come into play to any great extent. If the green square is placed on a blue ground the image becomes violet, for the reason that the blue light which is presented to the fatigued retina acts, as explained in Chapter IX., on the green and violet nerves; but the green nerves being already fatigued, the action is mostly confined to the violet nerves, and hence the corresponding sensation. In this case the red nerves hardly come into play at all.

It follows, from the above examples and reasoning that the final effect is, that we obtain as an after-image what amounts to a mixture

of the *complementary* color of the small square with the color of the ground; and, by recollecting this, we can easily retain this class of facts in the memory.

There is another similar experiment, which is simpler than those just described, but which nevertheless is instructive: A small square of *black* paper is to be placed on a sheet of red paper, and the attention in this case is to be directed to a mark on the edge of the former (*see* Fig. 6). When the black square is suddenly removed, the observer sees in place of it a more luminous spot, which in the case before

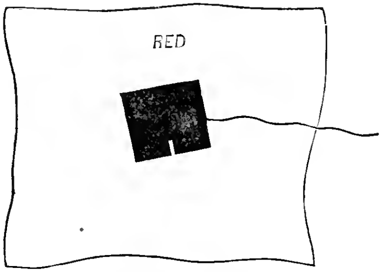


Fig. 6.—Red Ground with Black Paper.

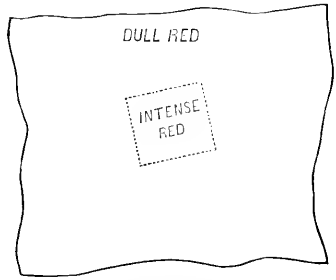


Fig. 7.—Red Ground with Intense Red Image.

us will, of course, be red; but what is remarkable is the circumstance that this red image will be more intense or saturated in color than the rest of the ground. The rest of the sheet of red paper will look as though gray had been mixed with its color (Fig. 7). This experiment will, of course, succeed with paper of any bright color, and Helmholtz has found that the same effect can be obtained with the pure colors of the prismatic spectrum. The explanation, according to our theory, runs about thus: While we are in the act of looking at the edge of the black square, red light is passing into the eye, and is fatiguing all those portions of the retina that are not protected by the presence of the black square; it thus happens that the ability of the larger portion of the retina to receive the sensation of red is considerably diminished; the ability of the protected portion, of course, suffers meanwhile no such change. When the black square is suddenly removed, the unfatigued portion of the retina receives a powerful impulse from the red surface, but the effect produced upon the rest of the retina is inferior in degree. This accounts for the fact that the image of the square is brighter or more luminous, and we can easily understand why it is at the same time more intense or saturated in color, if we remember, as explained in Chapter IX., that red light excites into action not only the red nerves, but to a lesser extent the green and violet nerves. Now, as the red nerves begin to be fatigued, the action of the other two sets will be relatively more powerful than at first, so that gradually the sensations of green and violet begin to add themselves to that of red, or, what is the same thing, the sensation

of white mingles itself with that of red and makes the red color of the paper look a little grayish. The success of the experiment with the pure colors of the spectrum, which contain no white, is easily accounted for by the explanation just given.

All these phenomena are cases of what is called successive contrast, because we look in succession from one surface to another. When colored surfaces are placed near each other and compared in a natural manner, successive contrast plays an important part, and the appearance of the colors is more or less modified according to its laws. If we attempt to confine our attention to only one of the colored surfaces, this still holds good, for the eye involuntarily wanders to the other, and to prevent this requires a good deal of careful practice, for fixed vision is quite opposed to our natural habit. It follows from this that, in the natural use of the eye, the negative images, although present to some extent, are not sharp and distinct, and hence usually remain unobserved by persons not trained to observations of this character. Nevertheless these images modify to a considerable extent the appearances of colored surfaces placed near each other, and the changes of hue are visible enough to the most uneducated eye.

One of the most common cases belonging here is represented in Fig. 8. We have a gray pattern traced on a green ground; the

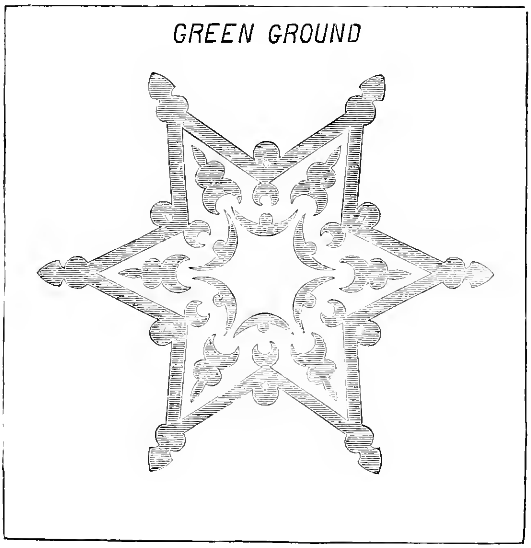


FIG. 8.—GRAY FIGURE ON A GREEN GROUND.

tracery, however, will not appear pure gray, but tinged with a color complementary to that of the ground; that is, reddish. We can, of course, substitute for the green any other bright color, and it will always be found that the gray pattern is more or less tinged with the

complementary hue. As black is really a dark gray, we should expect to find it also assuming, to some extent, a color complementary to that of the ground, and this is indeed the case, though the effect is not quite so marked as with a gray of medium depth. Chevreul, in his great work on the simultaneous contrast of colors, relates an anecdote which illustrates the matter now under consideration: Plain red, violet-blue, and blue woven stuffs were given by certain dealers to manufacturers, with the request that they should ornament them with black patterns. When the goods were returned the dealers complained that the patterns were not black, maintaining that those traced on the red stuffs were green; on the violet, dark greenish-yellow; and on the blue, copper-colored. Chevreul covered the grounds with white papers in such a manner as to expose only the patterns, when it was found that their color was truly black, the effects which had been observed being entirely due to contrast. The remedy in such cases is not to employ pure black, but to give it a tint like that of the colored ground, taking care to make it just strong enough to balance the hue generated by contrast. If we substitute a white pattern for the black, something of this same effect can often be observed, but it is less marked than with gray or black. In cases like those now under consideration, the contrast is stronger when the colored surface is bright and intense or saturated in hue. The effect is also increased by entirely surrounding the second color with the first; the circumscribing color ought also to be considerably larger than its companion. When these conditions are observed, the effect of contrast is generally noticeable only on the smaller sur-

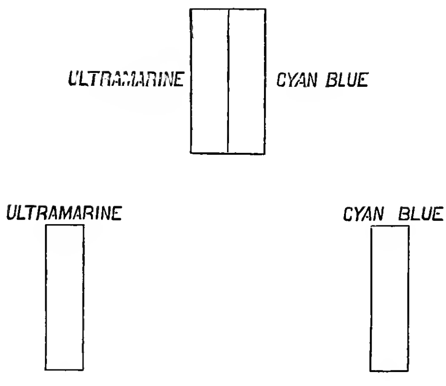


Fig. 9.—Arrangement to show the Effects of Simultaneous Contrast (One-half Size).

face, the larger one being scarcely affected. When, on the other hand, the two colored surfaces are about equal in extent, then both suffer change. If it is desired to produce a strong effect of contrast, the colored surfaces must be placed as near each other as possible. This is beautifully illustrated in one of the methods employed by Chevreul in studying the laws of contrast. Two colored strips were placed side by

side in contact, as shown in Fig. 9, duplicate strips being arranged in the field of view at some distance from each other. The tints of the two central strips were both altered; those placed at a greater distance apart suffered no change. In the experiment represented in Fig. 9, the central ultramarine by contrast is made to appear more violet, the central cyan-blue more greenish; the color of the outlying strips is scarcely affected.

As it requires a little consideration to predict the changes which colors undergo through contrast, we give below a table containing the most important cases:

Pairs of Colors.	Change due to Contrast.	Pairs of Colors.	Change due to Contrast.
Red	becomes more purplish.	Orange	becomes more yellowish.
Orange	" yellowish.	Violet	" bluish.
Red	" purplish.	Yellow	" orange-yellow.
Yellow	" greenish.	Green	" bluish-green.
Red	" brilliant.	Yellow	" orange-yellow.
Blue-green	" "	Cyan-blue	" blue.
Red	" orange-red.	Yellow	" brilliant.
Blue	" greenish.	Ultramarine-blue	" "
Red	" orange-red.	Green	" yellowish-green.
Violet	" bluish.	Blue	" purplish.
Orange	" red-orange.	Green	" yellowish-green.
Yellow	" greenish-yellow.	Violet	" purplish.
Orange	" red-orange.	Greenish-yellow	" brilliant.
Green	" bluish-green.	Violet	" "
Orange	" brilliant.	Blue	" greenish.
Cyan-blue	" "	Violet	" purplish.

It is easy and instructive to study the changes produced by contrast with the aid of a chromatic circle (Fig. 10), and it will be found that alterations in color produced by contrast obey a very simple law: when any two colors of the chromatic circle are brought into competition or contrasted, the effect produced is, apparently, to move them both farther apart. In the case, for example, of orange and yellow, the orange is moved toward the red, and assumes the appearance of reddish-orange; the yellow moves toward the green, and appears for the time to be greenish-yellow. Colors which are complementary are already as far apart in the chromatic circle as possible, hence they are not changed in hue, but merely appear more brilliant and saturated. This is indeed the effect which a strict application of our rule

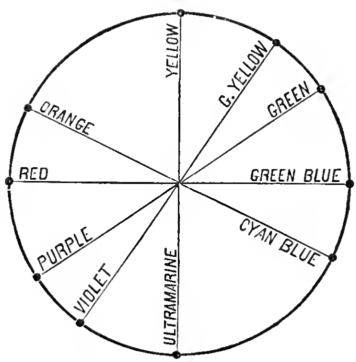


FIG. 10.—CHROMATIC CIRCLE.

leads to: The two colors are to be moved farther apart; they are already situated on the opposite extremities of a diameter of the circle, and, if they are to recede still farther from each other, they can accomplish this in no other way than by moving outside of the circumference of the circle; but this corresponds, as explained in the previous chapter, to an increase of saturation. If the experiments indicated in the previous table are carefully repeated, it will be found that all the pairs of colors there enumerated are not equally affected by contrast. The changes of tint are greatest with the colors which are situated nearest to each other in the chromatic circle, and much less with those at a distance. Thus both red and yellow are much changed by contrast, the red becoming purplish, the yellow greenish, while red with cyan-blue, or blue, is much less affected in the matter of displacement or change of hue. On the other hand, the colors which are distant from each other in the chromatic circle, while suffering but slight changes in hue, are made to appear more brilliant and saturated—that is, they are virtually moved somewhat outside of the circle, the maximum effect taking place with colors which are complementary. Colors which are identical are affected by contrast in exactly the opposite way from those which are complementary—that is, they are made to appear duller and less saturated. The author finds that these and other effects of contrast can be studied with great advantage by the aid of two identical chromatic circles laid down on paper. One set of these lines should be traced on a sheet of transparent paper, which is afterward to be placed over the companion-circle. The use of these circles will best be made evident with the aid of an example: Let us suppose that we wish to ascertain with their aid the effect produced by red, as far as contrast goes, on all the other colors, and also on red itself. We place the transparent circle on its companion so that the two drawings may coincide in position, and we then move the upper circle along the diameter joining the red and green-blue some little distance, so that the two circles no longer have the same common centre. We then transfer the points marked red, orange, yellow, etc., on the upper circle, by pricking with a pin through to the lower circle; these pin-marks on the lower circle will indicate the changes produced on all the colors by competition with red. Fig. 11 gives the result. The dotted circle with the crosses represents the new positions of the different colors when contrasted with red. If we examine it we find that red, when contrasted with greenish-blue, causes this last color to move away from the centre of the circle in a straight line; hence, as the new point is on the same diameter, but farther from the centre, we know that the greenish-blue is not made more or less blue or green, but is simply caused to appear more saturated or brilliant. The new point for the red lies also on the same diameter, but is nearer to the centre of the circle; that is, the color remains red, but appears duller or less saturated. Experience confirms this: if a considerable number of pieces of red cloth are ex-

amined in succession, the last one will appear duller and inferior in brilliancy to the others, but it will still appear red.

Proceeding with the examination of the effects produced on the other colors, we find that orange has been moved toward yellow, and also toward the centre of the circle; hence our diagram tells us that red, when put into competition with orange, causes the latter to appear

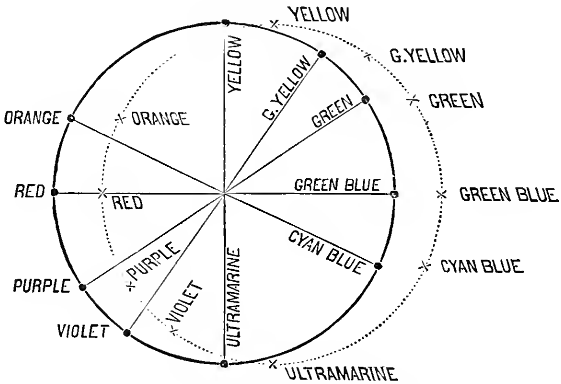


FIG. 11.—CHROMATIC CIRCLE DISPLACED BY CONTRAST (shows the effects produced by red upon the other colors).

more yellowish, and at the same time less intense. Advancing along the circumference of the circle, our diagram informs us that yellow is not much affected in the matter of saturation or intensity, but is simply made to appear more greenish. The two circles during superposition cut each other near the position of yellow; from this point onward the effect changes as far as intensity or saturation is concerned, the greenish-yellow being moved decidedly outside of the original circle as well as toward the green; it is made, therefore, by contrast with red, to appear more brilliant as well as more greenish. Green is made to appear somewhat bluish and more brilliant. Greenish-blue has been considered. Cyan-blue is made to appear slightly more greenish as well as much more brilliant; the same is true of blue, though its increase in brilliancy by contrast with red is rather less than is the case with cyan-blue. Violet has its hue considerably altered toward blue; its saturation is diminished. Purple is made to look more violet and is much diminished in saturation.

If we wish to study the effects produced on the colors of the chromatic circle by contrasting them with yellow, we have of course merely to displace the upper circle along the line joining yellow and its complement, ultramarine-blue, and then proceed as before.

It is quite evident that this contrast-diagram will furnish correct results only on condition that the colors in it are properly arranged; if the angular positions of the colors are laid down falsely, the results in the matter of increase or diminution of brilliancy will also be false.

The author has made many experiments to settle this question, and in Fig. 12 gives his result in the form of a diagram.

From the foregoing, then, it is evident that the effect of contrast may be helpful or harmful; by it colors may be made to look more beautiful and precious, or they may damage each other and appear dull, pale, or even dirty. When the apparent saturation is increased, we have the first effect; the second, when it is diminished. Our diagram (Fig. 11) shows that the saturation is diminished when the contrasting colors are situated near each other in the chromatic circle, and increased when the reverse is true. It might be supposed that we could easily over-

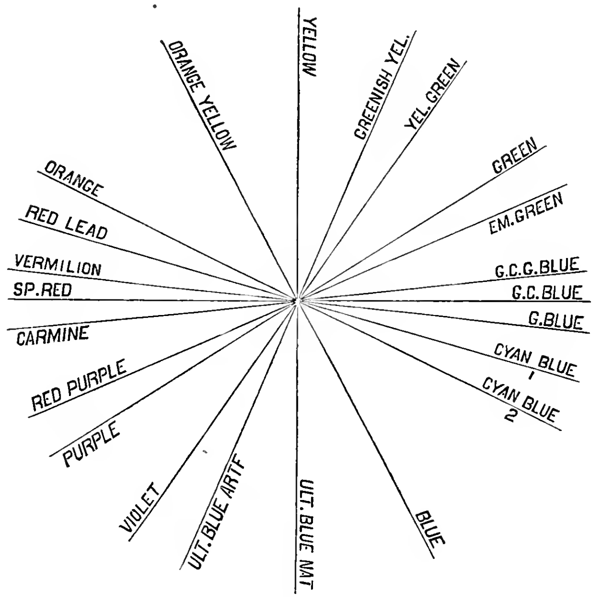


Fig. 12.—Contrast-Diagram, according to O. N. Rood.

come the damaging effects of harmful contrast by simply making the colors themselves from the start somewhat more brilliant; this, however, is far from being true. The pleasure due to helpful contrast is not merely owing to the fact that the colors appear brilliant or saturated, but that they have been so disposed and provided with such companions that they are made to glow with *more* than their natural brilliancy. Then they strike us as precious and delicious, and this is true even when the actual tints are such as we would call poor or dull in isolation. From this it follows that paintings made up almost entirely of tints that by themselves seem modest and far from brilliant, often strike us as being rich and gorgeous in color; while on the other hand the most gaudy colors can easily be arranged so as to produce a depressing effect on the beholder. We shall see hereafter that, in making

chromatic compositions for decorative purposes or for paintings, artists of all times have necessarily been controlled to a considerable extent by the laws of contrast, which they have instinctively obeyed, just as children in walking and leaping obey the law of gravitation, though hardly conscious of its existence.

The phenomena of contrast as exhibited by colors which are intense, pure, and brilliant, are to be explained to a considerable extent by the fatigue of the nerves, as set forth in the early part of the present chapter. The changes in color and saturation become particularly conspicuous after somewhat prolonged observation, and are often attended with a peculiar soft glimmering, which seems to float over the surfaces, and, in the case of colors that are far apart in the chromatic circle, to lend them a lustrous appearance. Still, upon the whole, the effects of contrast with brilliant colors are often not strongly marked at first glance, from the circumstance that the colors, by virtue of their actual intensity and strength, are able to resist these changes, and it often requires a practised eye to detect them with certainty. The case is quite otherwise with colors which are more or less pale or dark—that is, which are deficient in saturation, or luminosity, or both. Here the original sensation produced upon the eye is comparatively feeble, and it is hence more readily modified by contrast. In these cases the fatigue of the nerves of the retina plays but a very subordinate part, as we recognize the effects of contrast at the first glance. We have to

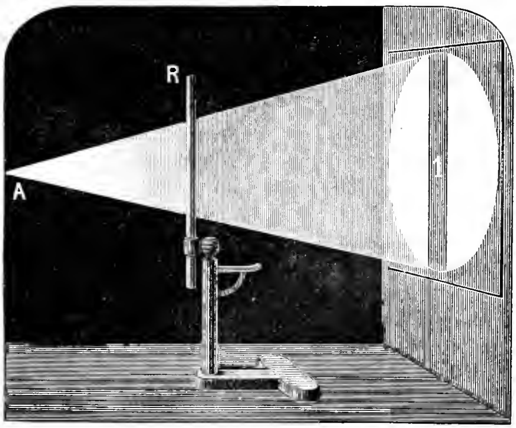


FIG. 13.—SHADOW OF ROD IN A DARKENED ROOM.

deal here with what is known as simultaneous contrast, the effects taking place when the two surfaces are, as far as possible, regarded simultaneously. In the case of simultaneous contrast, the changes are due mainly to fluctuations of the judgment of the observer, but little to the fatigue of the retinal nerves. We carry in ourselves no standard by

which we can measure the saturation of color or its exact place in the chromatic circle ; hence, if we have no undoubted external standard at hand with which to compare our colors, we are easily deceived. A slip of paper, of a pale but very decided blue-green hue, was placed on a sheet of paper of the same general tint, but somewhat darker and more intense or saturated in hue. The small slip now appeared pure gray, and by no effort of the reason or imagination could it be made to look otherwise. In this experiment no undoubted pure gray was present in the field of view for comparison, and, in point of fact, the small slip did actually approach a pure gray in hue more nearly than the large sheet; hence the eye instantly accepted it for pure gray. The matter did not, however, stop here : a slip of pure gray paper was now brought into the same green field, but, instead of serving as a standard to correct the illusion, it assumed at once the appearance of a reddish-gray. The pure gray slip really did approach reddish-gray more than the green field surrounding it, and hence was accepted for this tint.

It has been stated above that the effects produced by simultaneous contrast are due not to retinal fatigue, but to deception of the judgment ; now, as the effects of simultaneous contrast are identical in kind with those generated by successive contrast, it is evident that the statement needs some proof. This can be furnished with the aid of a beautiful experiment with colored shadows. In making this experiment, we allow white daylight to enter a darkened room through an aperture, *A*, arranged in a window, as indicated in Fig. 13. At *R* we set up a rod

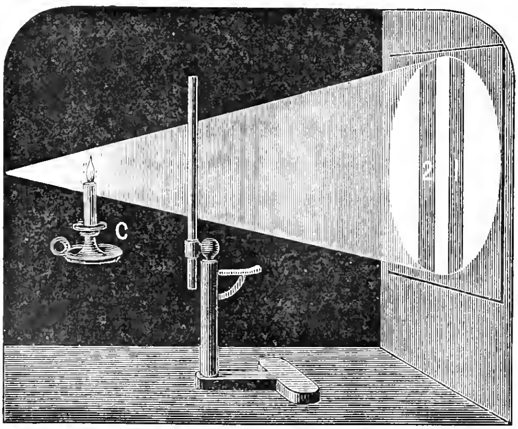


Fig. 14.—Shadows of Rod, using Daylight and Candle-Light.

and allow its shadow to fall on a sheet of white cardboard or on the white wall of the room. It is evident, now, that the whole of the cardboard will be illuminated with white light, except those portions occupied by the shadow, 1. We then light the candle at *C* (Fig. 14) ; its light will also fall on the cardboard screen, and will then cast the

shadow 2—that is, the candle-light will illuminate all parts of the screen except those occupied by the shadow 2; this portion will be illuminated with pure white light. Instead, however, of appearing to the eye white, the shadow 2 will seem to be colored decidedly *blue.*

For the production of the most powerful effect, it is desirable that the shadows should have the same depth, which can be effected by regulating the size of the aperture admitting daylight. Now, although the shadow cast by the candle is actually pure white, yet, by contrast with the surrounding orange-yellow ground, it is made to appear decidedly blue. So strong is the illusion that, even after the causes which gave rise to it have disappeared, it still persists, as can be shown by the following experiment of Helmholtz:

While the colored shadows are falling on the screen, they are to be viewed through a blackened tube of cardboard held in such a way that the observer has both the shadows in his field of view; the appearance, then, will be like that represented in Fig. 15. After the blue shadow

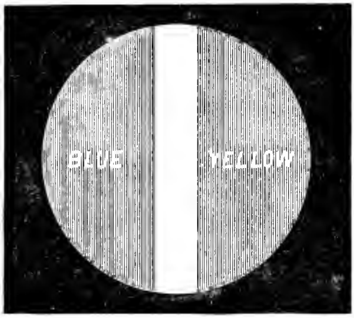


Fig. 15.—Blue and Yellow Shadows viewed through a Tube.

has developed itself in full intensity, the tube is to be moved to the left, so that the blue shadow may fill the whole field. The tube being held steadily in the new position, the shadow will still continue to appear blue instead of white, even though the exciting cause, viz., the orange-yellow candle-light, is no longer acting on the eye. The candle may be blown out, but the surface will still appear blue, as long as the eye is at the tube. On removing the tube, the illusion instantly vanishes, and it is perceived that the color of the surface is identical with that of the rest of the screen, which is at once recognized as white. In a case like this, the fatigue of the retinal elements can play no part, as the illusion persists for a far longer time than is necessary for their complete rest; we must hence attribute the result to a deception of the judgment.

The simple experiments of H. Meyer are less troublesome than those just described, and at the same time highly instructive. A small strip of gray paper is placed on a sheet of green paper, as indicated

in Fig. 16; it will be found that the tint of the gray paper scarcely changes, unless the experimenter sits and stares at the combination for some time. A sheet of thin white tissue-paper is now to be placed over the whole, when it will instantly be perceived that the color of the small slip has been converted by contrast into a pale red. Persons seeing this illusion for the first time are always much astonished. Here we have an experiment showing that the contrast produced by strong saturated tints is much feebler than with tints which are pale or mixed with white light, for, by placing tissue-paper over the green sheet, the color of the latter is extraordinarily weakened and mixed with a large quantity of white light. In this experiment it often happens that the red, which is due to contrast alone, seems actually stronger than the green ground itself. If, instead of using a slip of gray paper, we employ one of black, the contrast is less marked, and still less with one of white. It is scarcely necessary to add that, if red paper is employed instead of green, the small gray slips become tinted by contrast with the complementary color—i. e., greenish-blue; the same is true with the other colors. By preparing with India-ink a series of slips of gray paper, ranging from pure white to black, an interesting series of observations can be made on the conditions most favorable for the production of strong contrast-colors. The strongest contrast will be produced in the case of red, orange, and yellow, when the gray slip is a little darker than the color on which it is placed, the reverse being true of green, blue, violet, and purple; in every case the contrast is weaker if the gray slip is much lighter or much darker than the ground. We must expect, then, in painting, to find that neutral gray will be more altered by pale tints of red, orange, or yellow, which are slightly lighter than itself, and that the gray will be less altered by these colors when differing considerably from it in luminosity; analogous conclusions with regard to green, blue, violet, and purple, can also be drawn. Saturated or intense colors in a painting have less effect on white or gray than colors that are pale; this was shown in the preliminary experiment when gray was placed on a ground of strong color. In repeating these experiments it will be noticed that the effect of contrast is stronger with green, blue, and violet, than with red, orange, or yellow—that is to say, it is stronger with the cold than with the warm colors.

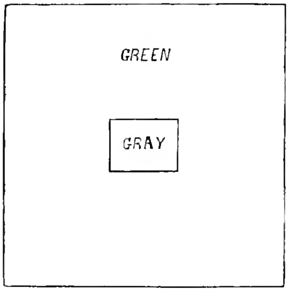


Fig. 16.—Green and Gray Papers for Experiment on Contrast (One-quarter Size).

We must next examine the effects that are produced by contrasting colors that differ in luminosity or in saturation. If the two colors are identical except in the matter of saturation, it will be found that the one which is more saturated will gain in intensity, while its pale rival

will appear still paler. A slip of paper painted with a somewhat pale red, when placed on a vermilion ground, appears still paler, and may actually be made to look white. If a *still paler* slip be used, it may even become tinged greenish-blue, its color being in this case actually reversed by the effect of contrast. When the colors differ in luminosity, analogous effects are observed: a dull-red slip was placed on a vermilion ground; the effect was as though a quantity of gray had been added to the slip; it looked more dingy and somewhat blackish. Another slip, still darker and containing less red, when placed on the same ground looked as if it were tinged with olive-green; a still darker slip, with still less red color, when treated in the same way looked black, with a tinge of blue. When, however, this last slip was placed on a white ground, or compared with true black, it was seen that its color was far from black. The general result of contrasting colors which differ much in strength then is, that the feebler one appears either more whitish or grayish, or assumes the complementary tint; the stronger one, on the other hand, appears still more intense.

If the strong and weak colors are complementary to each other, then each of them gains in intensity and appears purer, this gain seeming to be greater in the case of the pale tint. From this it follows that while the juxtaposition of strong with feeble colors usually injures or greatly alters the latter, colors that are complementary furnish an exception, the reason of which is evident at the first glance.

When the pale or dark colors are not complementary to their more intense or brilliant rivals, they undergo the same changes indicated in the table on page 7, the changes in the case of the dull or pale colors being considerably greater. In proportion as the colors are distant from each other in the chromatic circle, do they gain in saturation and beauty; while, as they approach, their character is altered and they are apt to look very pale, or, in the case of the dark colors, blackish or dirty. This is particularly so when the brilliant color is large in surface and surrounds the darker one; with the reversed conditions the effect is not so much felt. Thus, a somewhat dull red near vermilion no longer looks red but brown; a dull orange tint under the same conditions looks like a yellowish-brown.

It might be supposed, from what has preceded, that colors would enrich each other only when separated by a large interval in the chromatic circle, and from a purely physiological point of view this is indeed true; still there are other influences of a more spiritual character at work which modify, and sometimes even reverse, this lower law. Thus the presence of a pale color in a painting near that which is richer often passes unperceived, simply making the impression of a higher degree of illumination. We recognize the representation of a flood of light, and delight in it without finding fault with the pale tints, if only they are laid with decision and knowledge; again, pale color we delight in as representing the distance of a landscape; the pale greenish-gray,

bluish-gray, and faint tints of purple, which make it up, we never think of putting into envious competition with the rich, intense colors of the foreground, but enjoy each separately, and rejoice in the effects of atmosphere and distance which neither alone by itself could adequately render. That is to say, for the sake of light and atmosphere or distance, we gladly sacrifice a large portion of the powerful tints at our disposal and consider ourselves gainers. The same is also true in another direction: we are ready to make the same sacrifice for the sake of avoiding monotony and gaining variety, provided only we can justify the act by a good reason. Cases of this kind often occur in large masses of foliage, which, if of the same general color, are apt in a painting to look monotonous and dull, unless great labor is bestowed in rendering the light and shade and the small differences of tint which actually exist in Nature. Under such circumstances the observer feels a certain relief at the presence of a few groups of foliage, which are decidedly paler in color than the surrounding masses, provided only there is a good excuse for their introduction. Again, the mere contrast of dark or dull tints enhances the color and luminosity of those that are bright, and the observer receives the impression that he is gazing at a mass of gay and beautiful coloring, scarcely noticing the presence of the much larger quantity of tints that are darkened by being in deep shade. These darkened shade-tints are usually not variations of the same hue as the brighter ones, but are more bluish, so that technically these combinations would often present instances of harmful contrast, were it not for the fact that the bright and dull tints do not belong even to the same chromatic circle, but to circles situated in different planes, as explained in the previous chapter. Putting this into more ordinary language, we should say simply that the strong contrast of light and shade masked such effects of harmful color-contrast as were present. There is, however, another case where we are not so indifferent or so lenient: if two objects are placed near each other in a painting, and there is good reason why both should display the same color with equal intensity, if one is painted with rich color, the other with a pale or dark shade of the same color, then the latter will look either washed out or dirty, and a bad effect will be produced. As a familiar illustration of this kind of effect, we may allude to the use in dress of two widely-differing shades of ribbon which have still the same general color.

There is a still more general reason upon which the pleasure that we experience from contrast depends: after gazing at large surfaces filled with many varieties of warm color, skillfully blended, we feel a peculiar delight in meeting a few mildly contrasting tints; they prevent us from being cloyed with all the wealth of rich coloring so lavishly displayed, and their faint contradiction makes us doubly enjoy the richer portions of the painting. So also when the picture is mainly made up of cool bluish tints; it is then extraordinarily strengthened and brightened by a few touches of warm color.

THE EVOLUTION OF CEREMONIAL GOVERNMENT.

By HERBERT SPENCER.

VII.—TITLES.

THE undeveloped human intelligence does not initiate. Adhering tenaciously to whatever his fathers taught him, the primitive man deviates into novelty only through unintended modifications. That which every one now knows holds of languages, that they are not devised but evolve, equally holds of usages. To many proofs of this the foregoing chapters of this series have added further proofs.

The like holds of titles. Looked at as now existing, these appear artificial: there is suggested the idea that they were at some time or other consciously settled. But this is no more true than it is true that our common words were once consciously settled. Names of objects and qualities, and acts, are at first directly or indirectly descriptive; and the names we class as titles are in this respect like all others. Just as the deaf-mute who calls to mind a person he means by mimicking a peculiarity has no idea of introducing a symbol, so neither has the savage, when he recalls a place as the one where the kangaroo was killed or the one where the cliff fell down; so neither has he when he suggests an individual by referring to some marked trait in his appearance or fact in his life; and so neither has he when he gives those names, literally descriptive or metaphorically descriptive, which now and again develop into titles.

The very conception of a proper name grew up unawares. The fact that among the uncivilized a child is for years known as "Thunder-storm," or "New Moon," or "Father-come-home," shows us that there was originally nothing more than a reference to an event which occurred on its birthday, as a way of raising the thought the particular child meant. And if afterward it gets such a name as "Squash-head," or "Dirty-saddle" (Dakota names), this results from spontaneously using an alternative, and sometimes better, means of identification. Evidently the like has happened with such less needful names as titles. These must have differentiated from ordinary proper names, simply by being descriptive of some trait, or some deed, or some function, held in honor.

Various savage races give a man a name of renown in addition to, or in place of, the name by which he was previously known, on the occasion of a great achievement in battle. The Tupis furnish a good illustration. "The founder of the [cannibal] feast took an additional name as an honorable remembrance of what had been done, and his female relations ran through the house shouting the new title." And

of these same people, Hans Stade says: "So many enemies as one of them slays, so many names does he give himself; and those are the noblest among them who have many such names." In North America, too, when a young Creek Indian brings his first scalp he is dubbed a man and a warrior, and receives a "war-name." Among the more advanced people of ancient Nicaragua, this practice had established a general name for such: they called one who had killed another in battle *tapalique*; and *cabra* was an equivalent title given by the Indians of the Isthmus.

How descriptive names of honor, thus arising during early militancy, become in some cases official names, we see on comparing evidence furnished by two sanguinary and cannibal societies in different stages of advance. In Feejee, "warriors of rank receive proud titles, such as 'the divider of' a district, 'the waster of' a coast, 'the depopulator of' an island—the name of the place in question being affixed." And then in ancient Mexico the names of offices filled by the king's brothers or nearest relatives were, one of them, "Cutter of men," and another, "Shedder of blood."

Where, as among the Feejeeans, the conceived distinction between men and gods is vague, and the formation of new gods by apotheosis of chiefs continues, we find the gods bearing names like those given during their lives to ferocious warriors. "The Woman-stealer," "the Brain-eater," "the Murderer," "Fresh-from-slaughter," are naturally such divine titles as arise from descriptive naming among ancestor-worshiping cannibals. That sundry titles of the gods worshiped by superior races have originated in a kindred manner, is implied by the ascription of conquests to them. Be they the Egyptian deities, the Babylonian deities, or the deities of the Greeks, their power is represented as having been gained by battle; and with accounts of their achievements are in some cases joined congruous descriptive names, such as that of Mars—"the Blood-stainer," and that of the Hebrew god—"the Violent One;" which, according to Keunen, is the literal interpretation of Shaddai.

Very generally among primitive men, instead of the literally descriptive name of honor, there is given the metaphorically descriptive name of honor. Of the Tupis, whose ceremony of taking war-names is instanced above, we read that "they selected their appellations from visible objects, pride or ferocity influencing their choice." How such names, first spontaneously given by applauding companions, and afterward accorded in some more deliberate way, are apt to be acquired by men of the greatest prowess, and so to become names of rulers, is suggested by what Ximenez tells us respecting the more civilized peoples of Guatemala. Their king's names enumerated by him are—"Laughing Tiger," "Tiger of the Wood," "Oppressing Eagle," "Eagle's Head," "Strong Snake," etc. Throughout savage Africa there is a like

genesis of royal titles. The King of Ashantee has among his glorifying names "Lion" and "Snake." In Dahomey, titles thus derived are made superlative: the king is "the Lion of Lions." And in a kindred spirit the King of Usambara is called "Lion of Heaven:" a title whence, should this king undergo apotheosis, myths of sundry kinds may naturally result. From Zulu-land, along with evidence of the same thing, there comes an illustration of the way in which names of honor derived from imposing objects, animate and inanimate, are joined with names of honor otherwise derived, and pass into certain of those forms of address lately dealt with. The titles of the king are—"The noble elephant," "Thou who art forever," "Thou who art as high as the heavens," "Thou who begettest the men," "The black one," "Thou who art the bird who eats other birds," "Thou who art as high as the mountains," "Thou who art the peacemaker," etc. Shooter shows us how these Zulu titles are used, by quoting part of a speech addressed to the king—"You mountain, you lion, you tiger, you that are black. There is none equal to you." Further, there is proof that names of honor thus originating pass into titles applied to the position occupied, rather than to the occupant considered personally; for Shooter says that a Caffre chief's wife "is called the Elephantess, while his great wife is called the Lioness."

Guided by such clews we cannot miss the inference that the use of animal-names as names of honor, traceable in the records of extinct historic races, similarly arose. If we find that now in Madagascar one of the king's titles is "Mighty Bull," and are reminded by this that to the conquering Rameses a like laudatory name is given by defeated foes, we can scarcely avoid suspecting that, from animal-names thus given to kings, there result the animal-names given as names of honor to deities; so that Apis in Egypt becomes an equivalent for Osiris and the Sun, and so that Bull similarly becomes an equivalent for the conquering hero and Sun-god Indra.

With titles derived from imposing natural objects and powers, it is the same. We have seen how among the Zulus the hyperbolic compliment to the king—"Thou art as high as the mountains"—passes from the form of a simile into the form of a metaphor when he is addressed as "you Mountain." And that the metaphorical name thus used sometimes becomes a proper name, proof comes to us from Samoa, where "the chief of Pango-Pango being now Maunga, or Mountain, that name must never be used in his presence." There is evidence that among the ruder ancestor-worshipers divine titles are similarly derived. The Chinooks and Navajos and Mexicans in North America, and the Peruvians in South America, regard certain mountains as gods; and since these gods have other names, the implication is that in each case an apotheosized man had received in honor either the general name Mountain, or the name of a particular mountain, as has happened in New Zealand. From complimentary comparisons to the sun, there re-

sult not only personal names of honor and divine names, but also official titles. On reading that the Mexicans distinguished Cortes as "the offspring of the Sun," that the Chibchas called the Spaniards in general "children of the Sun," and that in Tlascala Alvarado was named by the people "Sun"—on reading that "Child of the Sun" was the complimentary name often given to any one particularly clever in Peru, where the Incas, regarded as descendants of the Sun, successively enjoyed a title hence derived—we are enabled to understand how "Son of the Sun" came to be a title borne by the successive Egyptian kings, which was joined with proper names individually distinctive of them. And remembering how in Egypt, along with elaborate ancestor-worship, there went worship of living kings, we shall have no difficulty in seeing that as the kings, besides the solar title borne in common by them, took from the same original such special titles as "the Sun becoming victorious," "the Sun orderer of Creation," etc., there naturally resulted, among their gods arising by apotheosis, solar titles similarly specialized; as "the Cause of Heat," "the Author of Light," "the Power of the Sun," "the Vivifying Cause," "the Sun in the Firmament," and "the Sun in his Resting-place."

Given, then, the metaphorically-descriptive name and we have the germ from which grew up these primitive titles of honor; which, at first individual titles, become in some cases titles attaching to the offices filled.

To say that the words which in various languages are the equivalents of our word "God," are originally descriptive words, will be a startling proposition to those who, unfamiliar with the facts, credit the savage with thoughts like our own; and will be a repugnant proposition to those who, knowing something of the facts, yet persist in asserting that the conception of a universal creative power was possessed by man from the beginning. But whoever studies the evidence without bias will find proof that the general word for deity was at first simply a word expressive of superiority. Among the Feejeeans the name is applicable to anything great or marvelous; among the Malagasy to whatever is new, useful, or extraordinary; among the Todas to everything mysterious—so that, as Marshall says, "it is truly an adjective noun of eminence." Applied alike to animate and inanimate things, as indicating some quality above the common, the word is in this sense applied to human beings, both living and dead; but as the dead are supposed to have acquired mysterious powers of doing good and evil to the living, the word comes to be more especially applicable to them. Though ghost and god have with us widely-distinguished meanings, yet they are originally equivalent words; or rather, originally, there is but one word for the supernatural being. Besides being shown this by missionaries who have found no native word for god which did not also mean ghost, demon, or devil; besides being shown this by the Greeks

and Romans, who used for the spirits of deceased relatives the same word which they used for their great deities ; and besides being shown it by the Egyptians, in whose hieroglyphics the same "determinative" means, according to the context, god, ancestor, august person—we are shown it by the Hebrews, who applied the word *elohim* not only to their supreme supernatural being but also to ghosts : indeed, giving as they did this same name to living persons of power, they show us, just as primitive peoples at large do, that superiority of one or other kind is the sole attribute ascribed. And since in early belief the other-self of the dead man is equally visible and tangible with the living man, so that it may be slain, drowned, or otherwise killed a second time; since the resemblance is such that it is difficult to learn what is the difference between a god and a chief among the Feejeeans; since the instances of theophany in the "Iliad" prove that the Greek god, capable of being wounded by men's weapons, was in all respects so like a man that special insight was required to discriminate him—we see how naturally it results that the title "god," given to a powerful being commonly thought of as invisible, is often given to a visible powerful being : the title being applied under the belief that he may be the other-self of some dreaded man come back, even if it is not applied because of his natural superiority. Indeed, as a sequence of this theory, it almost inevitably happens that men transcending in capacity those around them are suspected to be these returned ghosts or gods, to whom unusual powers are ordinarily ascribed. Hence the fact that Europeans, considered as the doubles of their own deceased people, are called ghosts by Australians, New-Caledonians, Darnley-Islanders, Kroomen, Calabar people, Mpongwe, etc. Hence the fact that they are called by the alternative name gods by Bushmen, Bechuanas, East Africans, Fulahs, Khonds, Feejeeans, Dyaks, ancient Mexicans, Chibchas, etc. Hence the fact that, using the word in the sense above explained, superior men among uncivilized peoples occasionally call themselves gods; as do the pâlâs, a kind of priests among the Todas, and as do some chiefs among the New-Zealanders and among the Feejeeans.

The original meaning and application of the word being thus understood, we need feel no surprise on finding "God" used as a title of honor. The King of Loango is so called by his subjects, Battel tells us; and Krapf says the like of the King of Msambara. At the present time among wandering Arabs, the name "God" is applied in no other sense than as the generic name of the most powerful living ruler known to them. This makes more credible than it might otherwise be, the statement that the Grand Lama, personally worshiped by the Tartars, is called by them "God, the Father." It is in harmony with such other facts as that Radama, King of Madagascar, is addressed by the women who sing his praises as "O our God ;" and that to the Dahoman king the alternative word "Spirit" is used; so that, when he summons any one, the messenger says, "The Spirit requires you," and when he has

spoken, all exclaim, "The Spirit speaketh true." All which facts make comprehensible that assumption of Θεὸς as a title by ancient kings in the East which is to moderns so astonishing.

Descent of this name of honor into ordinary intercourse, though not common, does sometimes occur. After what has been said above, it will not appear strange that it should be applied to deceased persons; as, according to Motolinia, it was by the ancient Mexicans, who "called any of their dead *teotl* so and so—i. e., this or that god, this or that saint." And prepared by such an instance we shall understand the better its occasional use as a greeting between the living. Colonel Yule says of the Kasias, "The salutation at meeting is singular—'Kublé! O God!'"

The connection between "God" as a title and "Father" as a title becomes clear only on going back to those early forms of conception and language in which the two are undifferentiated. The fact that, even in so developed a language as Sanskrit, words which mean "making," "fabricating," "begetting," or "generating," are indiscriminately used for the same purpose, suggests how naturally in the primitive mind the living father, as begetter or visible causer of new beings, becoming at death a causer of new beings who is no longer visible, is associated in word and thought with dead and invisible causers at large, who, some of them acquiring preëminence, come to be regarded as causers in general —makers or creators. When Sir Rutherford Alcock remarks that "a spurious mixture of the theocratic and patriarchal elements forms the bases of all government, both in the Celestial and the Japanese Empires, under emperors who claim not only to be each the patriarch and father of his people, but also divine descent," he adds one to the many misinterpretations produced by descending from our high conceptions, instead of ascending from the low conceptions of the primitive man. For what he thinks a "spurious mixture" of ideas is, in fact, a normal union of ideas; which, in the cases named, has persisted longer than commonly happens in developed societies.

The Zulus show us this union very clearly. They have traditions of Unkulunkulu (literally, the old, old one), "who was the first man," "who came into being and begat man," "who gave origin to man and everything besides" (including the sun, moon, and heavens), and who is inferred to have been a black man because all his descendants are black. The original Unkulunkulu is not worshiped by them because he is supposed to be permanently dead; but instead of him the Unkulunkulus of the various tribes into which his descendants have divided are severally worshiped, and severally called "Father." Here, then, the ideas of a Creator and a Father are directly connected. Equally specific, or even more specific, are the kindred ideas conveyed in the answers which the ancient Nicaraguans gave to the question, "Who made heaven and earth?" After their first answers, "Tamagastad and Çipat-

toval," "our great gods whom we call *teotes*," cross-examination brought out the further answers—"Our fathers are these *teotes*;" "all men and women descend from them;" "they are of flesh and are man and woman;" "they walked over the earth dressed, and ate what the Indians ate." Gods and first parents being thus identified, fatherhood and divinity become allied ideas. The remotest ancestor supposed to be still existing in the other world to which he went, the creator of his descendants, "the old, old one," or "ancient of days," becomes the chief deity; and so "father" is not, as we suppose, a metaphorical equivalent for "god," but a literal equivalent.

Therefore it happens that among all nations we find it an alternative title. In the before-quoted prayer of the New-Caledonian to the ghost of his ancestor—"Compassionate father, here is some food for you; eat it; be kind to us on account of it"—we are shown that original identification of fatherhood and godhood to which all mythologies and theologies carry us back. We see the naturalness of the facts that the Peruvian Incas worshiped their father the Sun; that Ptah, the first of the dynasty of the gods who ruled Egypt, is called "the father of the father of the gods;" and that Zeus is "father of gods and men."

After contemplating these early beliefs in which the divine and the human are so little distinguished, or after studying the beliefs still extant in China and Japan, where the rulers, "sons of heaven," claim descent from these most ancient fathers or gods, it is easy to see how the name father, in its higher sense, comes to be applied to a living potentate. His proximate and remote ancestors being all spoken of as fathers, distinguished only by the prefixes grand, great-great, etc., it results that the name father, given to every member of the series, comes to be given to the last of the series still living. With this cause is joined a further cause. Where establishment of descent in the male line has initiated the patriarchal family, the name father, even in its original meaning, comes to be associated with supreme authority, and to be therefore a name of honor. Indeed, in nations formed by the compounding and recompounding of patriarchal groups, the two causes coalesce. The remotest known ancestor of each compounding group, at once the most ancient father and the god of the compound group, being continuously represented in blood, as well as in power, by the eldest descendant of the eldest, it happens that this patriarch, who is head not of his own group only but also of the compound group, stands to both in a relation analogous to that in which the apotheosized ancestor stands; and so combines in a measure the divine power, the paternal power, and the kingly power.

Hence the prevalence of this word as a royal title. It is used equally by American Indians and by New-Zealanders in addressing the rulers of the civilized. We find it in Africa. Of the various names for the king among the Zulus, the name father heads the list; and in Dahomey, when the king walked from the throne to the palace, "every in-

equality was pointed out, with finger-snappings, lest it might offend the royal toe, and a running accompaniment of 'Dadda! dadda!' (Grandfather! grandfather!) and of 'Dedde! dedde!' (softly! softly!) was kept up." In Asia, we find cases in which the titles "Lord Raja and Lord Father" are joined together. In Europe, at the present time, father is applied to the czar; and in ancient times, under the form *sire*, it was the common name for potentates of various grades—feudal lords and kings; and still continues to be one of the names used in addressing a monarch.[1]

More readily than usual, perhaps from its double meaning, has this title been diffused. Everywhere we find it becoming the name for any kind of superior. Not to the king only among the Zulus is the word "baba," father, used; but also by inferiors of all ranks to those above them. In Dahomey a slave applies this name to his master, as his master applies it to the king. And Livingstone narrates how he was referred to as "our father" by his attendants, as also was Burchell by the Bachassins. It was the same of old in the East; as when "his servants came near, and spake unto Naaman, and said, My father," etc.; and it is the same in the remote East at the present time. A Japanese "apprentice addresses his patron as 'father.'" In Siam "children of the nobles are called 'father and mother' by their subordinates;" and Huc narrates how he saw Chinese laborers prostrating themselves before a mandarin, exclaiming, "Peace and happiness to our father and mother!" Then, as a stage in the descent to more general use, may be noted its extension to those who, apart from their rank, have acquired the superiority ascribed to age: a superiority sometimes taking precedence of rank, as in Siam, and in certain ways in Japan and China. Such extension occurred in ancient Rome, where *pater* was at once a magisterial title and a title given by the younger to the elder, though not related; and in Russia, at the present time, the equivalent word is used to the czar, to a priest, and to any aged man. Eventually it spreads to young as well as old. Under the form *sire*, at first applied to feudal rulers, major and minor, the title of father originated our familar *sir;* once general among us in speech and still in letters.

A curious group of derivatives, common among uncivilized and semicivilized peoples, must be named. The wish to compliment by ascribing that dignity which fatherhood implies, has in many places led to the practice of replacing a man's proper name by a name which, while it recalls this honorable paternity, distinguishes him by the name of his

[1] Though the disputes respecting the origins of *sire* and *sieur* have ended in the conclusion that they are derived from the same root, meaning originally elder, yet it has become clear that *sire* was a contracted form in use earlier than *sieur* (the contracted form of *seigneur*), and hence acquired a more general meaning, which became equivalent to father. Its applicability to various persons of dignity besides the *seigneur*, is evidence of its previous evolution and spread; and that it had a meaning equivalent to father, is shown by the fact that in early French *grant-sire* is used as an equivalent for *grand-père*, and also by the fact that *sire* was not applicable to an unmarried man.

child. The Malays, says St. John, have "the same custom as the Dyaks of taking the name of their first-born, as Pa Sipi, the father of Sipi." Marsden names the usage as common in Sumatra; and Ellis illustrates it from Madagascar. It is so too among some Indian hill-tribes: the Kasias "address each other by the names of their children, as Pabobon, father of Bobon!" Africa also furnishes instances. Bechuanas addressing Mr. Moffat used to say, "I speak to the father of Mary;" and in the Pacific States of North America there are people so solicitous to bear this primitive name of honor that, until a young man has children, his dog stands to him in the position of a son, and he is known as the father of his dog.

The supremacy associated with age in patriarchal groups and in societies derived by composition from patriarchal groups, shown primarily in that honoring of parents which, as in the Jewish commandments, is put next to the worship of God, and secondarily in the honoring of old men in general, gives rise to a kindred but divergent group of titles. Age being dignified, words indicating seniority become names of dignity.

The beginnings may be discerned among the uncivilized: councils being formed of the older men, there arises a connection between the local name for an older man and an office of power and therefore of honor. Merely noting this, it will suffice if we trace among European peoples the growth of titles hence resulting. Among the Romans, *senator*, or member of the *senatus*, words having the same root with *senex*, was the name for a member of the assembly of elders; and in early times these senators or elders, otherwise called *patres*, represented the component tribes: father and elder being thus used as equivalents. From the further cognate word *senior*, we have, in derived languages, *signore*, *seigneur*, *senhor*; first applied to head-men, rulers, or lords, and then by diffusion becoming names of honor for those of inferior rank. The same thing has happened with *ealdor* or *aldor*. This, says Max Müller, "like many other titles of rank in the various Teutonic tongues, is derived from an adjective implying age;" so that "earl" and "alderman," both diverging from this root, are names of honor, similarly resulting from that social superiority which went along with age.

Whether or not the German title *Graf* should be added, is a moot point. If Max Müller is right in considering the objections of Grimm to the current interpretation inadequate, then the word originally means gray; that is, gray-headed.

We may deal briefly with the remaining titles which reillustrate, in their respective ways, the general principle set forth.

Like other names of honor that grew up in very early times, the name "king" is one concerning the formation of which there are differences of opinion. By general agreement, however, its remote source

is the Sanskrit *ganaka;* and "in Sanskrit, *ganaka* means producing, parent, then king." If this is the true derivation, we have simply an alternative title for the head of the family group, of the patriarchal group, and the cluster of patriarchal groups. The only further fact respecting it calling for remark is the way in which it becomes compounded to produce a higher title. Just as in Hebrew Abram, meaning "high father," came to be a compound used to signify the fatherhood and headship of many minor groups; and just as the Greek and Latin equivalents to our patriarch signified, by implication if not directly, a father of fathers—so in the case of the title "king" it has happened that a potentate recognized as dominant over numerous potentates has in many cases been descriptively called "king of kings." In Abyssinia this compound royal name is used down to the present time; ancient Egyptian monarchs assumed it; and it occurred also as a supreme title in Assyria. And here again we meet a correspondence between terrestrial and celestial titles. As "father" and "king" are applied in common to the visible and to the invisible ruler, so also is "king of kings."

This need for marking by a distinct or additional name the ruler who becomes head of many rulers leads to the introduction of other titles of honor. In France, for example, while the king was but a predominant feudal noble, he was addressed by the title of *sire*, which was a title borne by feudal nobles in general; but after the middle of the sixteenth century, when his supremacy became settled, the word "majesty" came into use as distinctively applicable to him. Similarly with the names of secondary potentates. In the earlier stages of the feudal period, the titles baron, marquis, duke, and count, were often confounded: the reason being that their attributes as feudal nobles, as guards of the marches, as military leaders, and as friends of the king, were so far common to them as to yield no clear grounds for distinction. But as the differentiation of functions progressed, these titles differentiated in their meanings.

> "The name 'baron,'" says Chéruel, "appears to have been the generic term for every kind of great lord, that of duke for every kind of military chief, that of count and marquis for every ruler of a territory. These titles are used almost indiscriminately in the romances of chivalry. When the feudal hierarchy was constituted the name baron denoted a lord inferior in rank to a count and superior to a simple knight."

That is to say, with the progress of political organization, and the establishment of rulers over rulers, certain titles became specialized for the dignifying of the superiors, in addition to those which they had in common with the inferiors.

As is shown by the above cases, special titles, like general ones, are not made, but grow—they are at first descriptive. Further to exemplify this descriptive origin, and also to exemplify the undifferentiated use of titles in early days, let me enumerate the several styles by which,

in the Merovingian period, the mayors of the palace were known, viz.: *major domûs regiæ*, *senior domûs*, *princeps domûs*, and in other instances *præpositus*, *præfectus*, *rector*, *gubernator*, *moderator*, *dux*, *custos*, *subregulus*. In which list (noting as we pass how our own title "mayor," said to be derived from the French *maire*, is originally derived from the Latin *major*, meaning either greater or elder) we are shown how further names of honor carry us back to words implying age as their originals; and how in place of these descriptive words the alternative words used are descriptive of functions.

Perhaps better in the case of titles than in any other case is illustrated the diffusion of ceremonial forms that are used to propitiate first the most powerful, then the less powerful, and, finally, all others.

Uncivilized and semi-civilized peoples, civilized peoples of past times, and existing civilized peoples, all furnish examples. Among Samoans "it is usual, in the courtesies of common conversation, for all to call each other chiefs. If you listen to the talk of little boys even, you will hear them addressing each other as *chief* this, that, and the other thing." In Siam, a man's children by any of his inferior wives address their father as "my lord, the king;" and the word Náï, which is the name for chief among the Siamese, "has become a term of civility which the Siamese give to one another." A kindred result has occurred in China, where sons speak of their father as "family's majesty," "prince of the family;" and China supplies a further instance, which is the more noteworthy because it is special. Here, where the supremacy of ancient teachers became so great, and where the titles *tze* or *futze*, signifying "great teacher," added to their names, were subsequently added to the names of distinguished writers, and where class distinctions based on intellectual eminence characterize the social organization, it has resulted that this name of honor, signifying teacher, has become an ordinary complimentary title. Ancient Rome furnishes other evidences. The spirit which led to the diffusion of titles is well exhibited by Mommsen in describing the corrupt giving of public triumphs that were originally accorded only to a "supreme magistrate who augmented the power of the state in open battle."

"In order to put an end to peaceful triumphators, . . . the granting of a triumph was made to depend on the producing proof of a pitched battle which had cost the lives of at least five thousand of the enemy; but this proof was frequently evaded by false bulletins. . . . Formerly the thanks of the community once for all had sufficed for service rendered to the state; now every meritorious act seemed to demand a permanent distinction. . . . A custom came into vogue, by which the victor and his descendants derived a permanent surname from the victories they had won. . . . The example set by the higher was followed by the humbler classes."

And under the influence thus illustrated, *dominus* and *rex* eventually became titles used to ordinary persons. Nor do modern European na-

tions fail to exemplify the process. The prevalence of names of rank on the Continent, often remarked, reaches in some places great extremes. In Mecklenburg, says Captain Spencer, "it is computed that the nobility include one-half of the population. . . . At one of the inns I found a Herr Graf [count] for a landlord, a Frau Gräfin [countess] for a landlady, the young Herren Grafen filled the places of hostler, waiter, and boots, while the fair young Fräulein Gräfinnen were the cooks and chambermaids. I was informed that in one village . . . . the whole of the inhabitants were noble except four."

French history shows us more clearly perhaps than any other the stages of diffusion. Just noting that in early days, while *madame* was the title for a noble lady, *mademoiselle* was used to the wife of an advocate or physician, and that when, in the sixteenth century, *madame* descended to the married women of these middle ranks, *mademoiselle* descended from them to the unmarried women, let us look more especially at the masculine titles *sire*, *seigneur*, *sieur*, and *monsieur*. Setting out with *sire*, as an early title for a feudal noble, we find, from a remark of Montaigne, that in 1580, though still applicable in a higher sense to the king, it had descended to the vulgar, and was not used for intermediate grades. *Seigneur*, introduced later as a feudal title, while *sire* was losing its meaning by diffusion, and for a period used alternatively with it, became, in course of time, contracted into *sieur*. By-and-by *sieur* also began to spread to those of lower rank. Afterward, reëstablishing a distinction by an emphasizing prefix, there came into use *monsieur*; which, as applied to great seigneurs, was new in 1321, and which came also to be the title of sons of kings and dukes. And then by the time that *monsieur* also had become a general title among the upper classes, *sieur* had become a *bourgeois* title. Since which time, by the same process, the early *sire* and the later *sieur*, dying out, have been replaced by the universal *monsieur*. So that there appear to have been three waves of diffusion: *sire*, *sieur*, and *monsieur*, have successively spread downward.

How by this process high titles eventually descend to the very lowest, we are shown most startlingly in Spain, where "even beggars address each other as Señor y Caballero—Lord and Knight."

For form's sake, though scarcely otherwise, it is needful to point out how we are taught here the same lesson as before. The title-giving among savages which follows victory over a foe, brute or human, and which literally or metaphorically distinguishes the individual by his achievement, unquestionably originates in militancy. Though the more general names father, king, lord, elder, and their derivatives, which afterward arise, are not directly militant in their implications, yet they are indirectly so; for they are the names of rulers evolved by militant activity, who habitually exercise militant functions: being in early stages always the commanders of their subjects in battle. Down to

our most familiar titles we have this genesis implied. "Esquire" and "Mister" are derived the one from the name of a knight's attendant and the other from the name *magister*—originally a ruler or chief, who was a military head by origin and a civil head by development.

As in other cases, comparisons of societies of different types disclose this relation in another way. Remarking that in sanguinary and despotic Dahomey the personal name "can hardly be said to exist; it changes with every rank of the holder," Burton says: "The dignities seem to be interminable; except among the slaves and the *canaille*, 'handles' are the rule, not the exception, and most of them are hereditary." So, too, under Oriental despotisms. "The name of every Burman," says Yule, "disappears when he gets a title of rank or office, and is heard no more;" and in China "there are twelve orders of nobility, conferred solely on the members of the imperial house or clan," besides "the five ancient orders of nobility." In Europe it is the same. Travelers in both Russia and Germany, with their social organizations subordinated to the purposes of war, comment on the "insane rage for titles of every description:" the results being that in Russia "a police-office clerk belongs to the eighteenth grade, and has the right to the title of Your Honor;" while in Germany the names of ranks and names of office, so abundantly distributed, are habitually expected and studiously given, in both speech and writing. Meanwhile England, for ages past less militant in type of structure, has ever shown this trait in a smaller degree; and along with the recent growth of industrialism and accompanying changes of organization, the use of titles in social intercourse has greatly decreased.

With equal clearness is this connection shown within each society. Names of honor pertain to members of that regulative organization which militancy originates. By the thirteen grades in our army and the fourteen grades in our navy, we are shown that the exclusively militant structures still continue to be characterized in the highest degree by numerous and specific titular marks. To the ruling classes, descendants or representatives of those who in past times were heads of military forces, the higher distinctions of rank still mostly belong; and of remaining higher titles, the ecclesiastical and legal are also associated with the regulative organization. Meanwhile the producing and exchanging parts of the society, carrying on industrial activities, only in exceptional cases bear any titles beyond those which, descending and spreading, have almost lost their meanings.

It is indisputable, then, that, serving first to commemorate the triumphs of savages over their foes, titles have expanded, multiplied, and differentiated, as conquest has formed larger societies by consolidation and reconsolidation of small ones; and that, belonging to the type of social structure generated by habitual war, they tend to lose their meanings, their uses, and their values, in proportion as this structure is replaced by one fitted for carrying on the pursuits of peace.

THE DIFFERENCES BETWEEN ANIMALS AND PLANTS.

By W. K. BROOKS.

THE original investigator of Nature soon learns by constant experience that descriptions or even drawings, however correct, do not exactly represent the objects themselves, but are imperfect and ideal abstractions. This is true, to a greater or less extent, of every drawing of the simplest organ or tissue, and of every description of a species or genus of animals or plants; but it is especially and most emphatically true of all attempts at definitions of the larger and more comprehensive groups of organisms.

A definition of such a group as an order or class of animals, attempting as it does to state in a few words the characteristics which are common to all the forms included, is necessarily abstract, and may not, in fact cannot, be exactly embodied in any one individual of the whole group. Then, too, certain characteristics which are exhibited by only one or two aberrant forms, and are accordingly not characteristic of the group as a whole, may be omitted from the definition, although they furnish the clew to the relationship with allied groups, and are therefore of the utmost importance. An illustration which is not drawn from the organic world may make this more evident. The fact that printed books have followed and are a perfected form of the parchment manuscripts of the middle ages is shown by the ornamental initial letters, imitations of the illuminated letters of the manuscripts, which are placed at the heads of the chapters of a few books. Notwithstanding their significance, these initial letters would not find a place in any definition or general description of a modern book.

As a consequence of this inevitable lack of agreement between natural objects and their definitions, all knowledge of Nature is of very little value unless it is based upon a direct personal acquaintance with Nature itself. How different, for instance, will be that conception of such a group as the *Cœlenterata*, which is formed by the study of a short, definite, verbal description, from the idea in the mind of the student whose knowledge of the group as a whole has been acquired gradually by the study and comparison of the various forms of life which it includes!

Definitions are valuable and indispensable aids to study, and, as long as their necessary lack of agreement with the reality is kept in mind, they can do no harm; but the history of science warns us to be constantly on our guard, lest distinctions which seem to be sharp and absolute, when stated in words, come to be regarded as having as real an existence in Nature as in words, and we thus come, in the words of Bacon, to exchange "things for words, reason for insanity, and the world for a fable."

The tenacity with which many thinkers still cling to a belief in the reality and absoluteness of such distinctions as those expressed by the terms "organic and inorganic," "living and dead," "animal and vegetable," "rational and instinctive," etc., is plainly the result of this tendency to attribute to Nature the exactness of words.

The terms *animal* and *plant* were not established as the result of scientific and thorough study and comparison, but were first introduced to give expression to the most superficial and obvious difference between living things.

Originally an animal was a living thing which could move and feel, and a plant one which could not; and this is still the popular view, although the scientific definitions are quite different. As soon as primitive man began to observe and to generalize and to use abstract words, one of the first generalizations which attracted his attention was that, of the bodies which were of most importance to him, and like him grew up, matured, and died, some were still more like himself in having the power to move and feel, while others lacked this power, and were fixed and insensible. We do not intend to imply that this generalization took this definite shape, but simply that it was reached and put into words at a very early period; and this is shown by the fact that in nearly all languages, and among all but the lowest races of men, this division of living things into two great groups is recognized, and definite words are employed to distinguish the animal from the vegetable organism. At a later period, when living things came to be more carefully studied, and superficial observation gave place to more exact and careful comparison, these two groups were found to have a real existence in Nature; and, as long as this study was confined to the more familiar, abundant, and easily-studied organisms, the increase of scientific knowledge only served to render the distinctness of the two groups more evident. It was soon found that all the common plants are alike in many other respects besides being fixed and insensible, and that all ordinary animals have many common characteristics, and it was found convenient to express these resemblances briefly and absolutely in definitions, and thus the terms *animal* and *plant* came to have a more and more exact and scientific value. It was seen, too, that all living things have much in common, and that the chief difference between plants and animals is the possession by the latter of the new properties of sensation and voluntary motion, added to those characteristics which they share with the plants. It is not at all strange that it was thought desirable to express this fact by a word, and that, in the same way that living things were said to differ from inorganic bodies by having, in addition to all the properties of the latter, a new and higher quality, *vitality*, animals were said to possess the new and higher faculties of *feeling* and *will*, in addition to all the faculties of the plant.

Thus was gradually built up that conception of Nature which re-

gards the three kingdoms—the mineral, the vegetable, and the animal—as three successive steps in an ascending series, each being supposed to have all the properties and characteristics of the groups below it, and something new and entirely different in addition. This conception admits of such brief and definite statement, and when put into words is so clear and simple, that its general acceptance is quite natural; and we need not be surprised that it only gives way very slowly in favor of a view which does not admit of the same definite and simple formulation.

We will now examine the reasons which have led modern thinkers to reject this view, and to hold that, real and actual as the differences between animals and plants are, they are by no means absolute.

The most conspicuous and superficial difference between animals and plants is the one which we have already noticed. Animals have the power of free locomotion and of independent action, which is determined within the animal; these powers are called into action by changes in the external world, and imply the existence of sensation and consciousness. In all the ordinary plants the power of locomotion is lacking, and there are no voluntary actions like those which result from the sensitiveness of the animal. This difference finds its expression in the well-known dictum of Linnæus: "Plantæ vivunt; animalia vivunt et sentiunt;" and upon it is based the classification of the functions and organs of the animal as those of vegetative and those of animal life. Those functions which are carried on independently of the will, and are not influenced directly by changes in the external world—digestion, assimilation, secretion, circulation, and reproduction, for example—are called the vegetative functions of the body; while those of relation, such as sensation and voluntary motion, are called, in contradistinction, the functions of animal life.

The difference which has led to the general acceptance and current use of these and many similar expressions is real, as far as the higher and more familiar animals and plants are concerned, but, with the growth of our knowledge of the lower forms of life, the necessity for expansion and modification of the definition of both groups becomes apparent. Many of the lower animals, such as the hydroids and sponges, as well as many highly-organized animals, like the tunicates and oysters, lack the power of locomotion; and, on the other hand, many of the lower plants are quite actively locomotive. Certain plants which are by no means low are quite sensitive to external changes, and the actions by which they respond to these changes in the Venus's-flytrap, for instance, give quite as good proofs of the existence of volition as are afforded by the actions of many of the lower animals.

Another superficial and easily-recognized distinction between animals and plants is afforded by the contrast in general form and structure; this, like the first, is real, as long as our attention is restricted to the higher forms of the two groups. In the animal we find a sharply

and definitely limited body, within which is a complicated mass of viscera, while in the plant the physiological equivalents of these, the nutritive and respiratory organs, are distributed in areas of considerable extent over the diffused and indefinite outer surface of the body. In the animal the absorbent surfaces of these organs are internal; in the plant, external. In nearly all the higher animals there is a mouth-opening, through which solid as well as liquid food may pass into the digestive cavity, which is furnished with specialized glandular appendages, such as the salivary glands, liver, etc. Within the digestive tract the food is elaborated and prepared for digestion and digested, and the indigestible refuse is discharged from the body through a definite anal opening. The nitrogenous products of decomposition are excreted from the body, usually in solution, by definite urinary organs. There is a muscular pulsating heart, by which the nutritive fluid or blood is propelled through blood-vessels with definite walls, and respiration is effected almost entirely by definite limited organs which are usually internal. The animal also has internal reproductive organs, as well as a nervous system and organs of sensation.

In the plants those organs which exist at all are present in a much simpler form. The roots absorb nutritive matter through their surfaces, usually as a fluid, and the surfaces of the leaves are the respiratory organs, absorbing and giving off gases. The complicated system of internal organs, so characteristic of the animal, is entirely wanting in the plant, and the internal substance of the latter is made up of a comparatively homogeneous parenchyma of cells and tubes, through which the fluids circulate. The reproductive elements are not formed in limited local internal glands, but externally, and there are no nerves or sense-organs.

This distinction is diagnostic but not perfectly characteristic; that is, we may safely classify as an animal any organism in which we find a definite, sharply-limited body, and complicated internal viscera, such as a digestive tract, respiratory organs, blood-vessels, internal reproductive organs, and a nervous system and sense-organs; while we may, with almost equal safety, refer to the vegetable kingdom an organism in which the nervous, sensory, and circulating organs are wanting, and the processes of absorption and respiration take place through the outer surface. This distinction is therefore diagnostic, for it enables us to determine, with considerable certainty, to which of the two groups a given organism is to be referred; but it is not characteristic, and cannot be made the basis of an absolute definition, for it gradually disappears as we study the lower animals and plants. As a matter of fact, each one of the peculiarities given above as distinctive of animals will be found lacking in organisms the animal nature of which is undoubted, and many animals will be found to want all of them. Even among the vertebrates the organs of respiration are greatly simplified in the lower forms. In the adult frog the skin aids the lungs in aërating

the blood, and is so thin and delicate, and so richly supplied with blood-vessels, that, when moistened, it readily admits of the interchange of gases. During the breeding-season the abdomen of the female frog is so distended by eggs that there is no room for the inflation of the lungs, and respiration is entirely carried on through the skin.

In those marine and aquatic animals of small size whose bodies are not covered by impervious shells, respiration may take place, as in plants, over the whole surface of the body ; and in many groups, the larger and protected members of which are furnished with highly-specialized respiratory organs, these organs may be entirely wanting in the smaller naked forms. This is the case, for instance, with many of the naked mollusks.

In place of a closed system of vessels for the circulation of the blood, this fluid may, in parts of its course, find its way through the spaces among the viscera, and in the Tunicata a pulsating heart keeps in motion a hæmal fluid, which is nowhere confined by distinct blood-vessels, but fills and circulates through all the intra-visceral spaces of the body. In most mollusks, again, the musculur movements of the various parts of the soft body aid the heart in maintaining the circulation ; and in the Polyzoa both vessels and heart are lacking, and the movements of the blood are due to muscular contractions, aided in many cases by cilia.

The salivary glands are frequently wanting in marine animals ; the water swallowed with the food taking the place of saliva. The liver and other appendages to the digestive tract are wanting in many of the lower animals, and a parasitic life may entirely do away with the need for them, even in an animal which belongs to a highly-specialized group. The ordinary gasteropod mollusks have digestive organs which are almost as highly specialized as those of a vertebrate ; but "entoconcha," a strange parasitic gasteropod, has no jaws or teeth, no salivary glands or liver, no anus, or any other specialized appendage to the digestive cavity, which is a simple pouch, which is not divided into œsophagus, stomach, and intestine, and the animal lives inside the body cavity of a holothurian, attached to the wall of its stomach, and is nourished by the fluids which it sucks from the digestive cavity of its host. In the sponges and hydroids there is no digestive cavity distinct from the body cavity, and the food is received directly into the latter. Even the mouth is wanting in many parasitic worms, and the liquid food is absorbed through the outer surface of the body, precisely as in plants, and some parasites put forth root-like processes which penetrate the tissues of the host and absorb its juices.

The nervous system and organs of special sense are wanting in many of the lower animals, and in the fresh-water hydra the reproductive organs are not formed in specialized internal glands at definite points, but resemble those of plants in making their appearance at many points upon the surface of the body.

Many of the lower animals resemble plants in their mode of growth, as well as in simplicity of structure; the colonies or clusters of the compound hydroids, and the coral-making polyps, are very plant-like, and, as they also lack the power of locomotion, their animal nature was for a long time disputed, and they were classified as plants.

However much the body of one of the higher animals differs in general form and structure from that of one of the higher plants, it is plain, from the facts which we have pointed out, that the two groups cannot be absolutely and arbitrarily separated upon this basis, although the general value of the distinction is obvious.

Histology furnishes another difference which is quite general but not universal. There are well-marked and pretty constant contrasts between the cells and tissues of the one group and those of the other, and these contrasts furnish what is, perhaps, the most constant morphological distinction. The constituent cells of the tissues of the plant retain their original form and individuality, while, in the animal, they undergo the greatest modifications, and their individuality is usually entirely lost. A vegetable tissue or organ may easily be shown to be made up of a mass of nearly similar cells, each of which is independent and sharply defined; while the tissues of animals present the greatest differences in structure and appearance, and sharply-defined individual cells are seldom to be seen. The cause of this difference in the appearance of the tissues is a difference in the cells themselves. The protoplasmic contents of the vegetable cell are inclosed by a thick, strong outer membrane or cellulose wall; while the outer surface of the animal cell is usually only a little more dense than the protoplasmic contents, and does not usually form a distinct cell-wall. The vegetable cell may, however, be destitute of the cellulose wall; and, on the other hand, many animal tissues—cartilage, for instance—resemble the tissues of plants in being made up of independent cells, each of which has an outer layer.

The most universal and characteristic difference between animals and plants is physiological, and relates to the nature of the food and the character of the nutritive process. From comparatively simple inorganic substances, such as water, carbonic acid, and ammonia, the plant is able to build up the highly-complex protein compounds which are so characteristic of living beings. The animal feeds, in part, upon inorganic substances, such as water, and certain carbonates and phosphates, but it derives all its protein from plants, either directly, or, as in the case of the carnivorous animals, indirectly, through the aid of vegetable-feeding animals. In the body of the animal the complex protein compounds are broken down into simpler substances, and the energy thus set free is converted into the various manifestations of "vital force." The animal organism is thus a consumer of protein and a liberator of force. The vital activities of the plant depend, like those of the animal, upon the liberation of energy by the breaking

down of protein compounds; but, as the formation of new protein within the body of the plant usually exceeds this consumption, plants, as manufacturers of protein, are broadly distinguished from animals. It is now known, however, that many very highly-organized flowering plants are carnivorous, and digest and make use of the protein of the animals which they capture, and it is probable that the potato-fungus and many other parasitic plants obtain all their protein ready made, like animals; and, as it is impossible to show that none of the lower animals have the power to make protein for themselves, this distinction cannot be made the basis of an absolute line between the two groups.

The difference in the process of respiration in animals and plants is well known. Animals while in a state of vital activity absorb oxygen from the air; and this is given off from their bodies, usually united with carbon, as carbonic acid. The green plants, on the contrary, absorb carbonic acid, which is separated by the chlorophyll, under the influence of sunlight, into carbon, which is appropriated by the plant, and oxygen, which is given off and may be again taken up by an animal. This difference is made use of in the arrangement of an aquarium; enough green plants being placed in the water to absorb the excess of carbonic acid given off by the animals, and to supply the oxygen for their respiration. The difference is not by any means absolute, however, since the vital changes of the plant are dependent, like those of the animal, upon oxidation, and result in the formation of carbonic acid. The colorless plants, like animals, absorb oxygen and give off carbonic acid. This is also true of green plants which are not exposed to light; but in the latter plants this process is normally masked and hidden by the opposite process already spoken of.

It is plain, from what has been said, that the separation of organisms into two great groups—animals and plants—is convenient and natural, and that the distinctions between them are real but not absolute; and it is possible to define, that is give, all the characteristics which are distinctive of an animal, without implying or assuming that all animals conform with the definition to the same degree, or that no plant shares any of the characteristics. Since the lower representatives of the two groups resemble each other more closely than the higher forms, and since all positive characteristics gradually disappear as we approach the point of union or origin, we must, in order to give our definition any definiteness whatever, neglect the lowest and simplest forms, and consider only the more specialized.

As shown by the highest forms, an animal may be described morphologically as an organism made up of cells, which are usually without a cell-wall or membrane. In the adult, the individuality of these cells is usually lost, since they are united to form membranes, tissues, and fibres. In nearly all animals the tissues thus built up from cells fall into four groups—epithelium, connective tissue, muscular tissue, and nervous tissue.

The organs of the body are composed mainly of these tissues, and present the greatest diversity of structure and function; but they may be roughly arranged, according to their functions, into four groups: organs of nutrition, such as the digestive, circulatory, and respiratory organs; organs of reproduction, organs of motion, and organs of relation, such as the nervous system and sense-organs, and organs of defense or protection, such as horns or spurs. Except among the lower and simpler groups the individuals are not organically united, as in plants, into a community, although such communities as pairs, or flocks, or herds, are frequent. In such a community as a hive of bees the different individuals are specialized for the good of the whole, and are unable to exist apart; and the community is as real as in the case of a plant, although the connection is not material, but purely ideal.

Physiologically, animals are characterized by the fact that, with few exceptions, they are able to receive solid food into a definite internal digestive cavity, in which it is digested, and then absorbed through the wall of the cavity. They absorb oxygen from the surrounding medium, air or water, and, in addition to certain inorganic substances, take into their bodies, as their proper nutritive material, complicated protein compounds, which they derive either directly or indirectly from plants. Through the oxidation of these compounds they form substances of a simpler chemical structure, such as carbonic acid, water, and ammonia, and discharge these through their bodies as waste. Since the sum of the chemical changes which take place in the animal is the breaking down of the highly-complex protein-molecules, derived from plants, into the simpler molecules of water, ammonia, and carbonic acid, it results that the potential energy thus set free is shown by the animal as "vital force," and the body of the animal is therefore a magazine or storehouse of force which may manifest itself as animal heat or light, or as sensible motion, or nervous disturbance; an animal, then, is an organism which has the power to change the potential energy of vegetable protein by oxidation into "vital force," which may manifest itself as animal heat, or, in the case of many marine animals, as light, or by peculiar disturbances of the nerves and muscles, organs which are peculiarly diagnostic of animals. The changes of the muscles result in motion, either of the animal as a whole or of the various parts in relation to each other. The structure and functions of the nervous system of one of the higher animals are so entirely different from any other phenomena, that they seem to be *sui generis* and peculiar; but we must not forget that there are true animals which entirely lack a nervous organization, and that in the history of each individual, as well as in the history of the animal kingdom, we may pass without any considerable break from animals with a complicated system of nerves and sense-organs to animals which give no evidence of conscious life, and are no more sensitive than ordinary plants. The nervous system of an animal may be roughly described as a regulative apparatus by which the vari-

ous parts of the body are brought into relation with each other, in such a way that a disturbance or change in one part shall bring about in another part the liberation of a certain amount of energy, which shall result in change tending to bring the organism into harmony with the conditions which determined the first change. In many cases the action of the nervous system is accompanied by consciousness, and in the higher animals it has a subjective existence as intelligence and volition.

Such, briefly stated, are the most important characteristics of animals as they are manifested by the higher representatives of the group, and it is hardly necessary to call attention again to the fact that none of them furnishes a basis for the absolute separation of animals and plants, or to point out again that many of them are met with only in the higher animals, while others are not confined to animals, but are shared by some plants. The two groups are related to each other somewhat like two streams which have their sources in the same watershed, but flow in different directions, and through regions of different characters. It is almost impossible to say whether the springs and marshes among which they rise belong to one stream or the other, and they may be connected with both; but, as we pass from this common source, the characteristics of each stream become more marked, until at last their differences, the result of the different conditions to which they have been exposed, overbalance and sink the resemblances which are due to their common source.

We must not suppose that this fact does away with the idea of the essential diversity of animals and plants, or that the distinction between them is any the less real and natural because they can be traced to a common source, and cannot be absolutely defined. As much confusion of ideas exists with reference to this point, it may not be out of place to give an illustration, drawn from another field, to show that a distinction may be real without being absolute:

A person in charge of a small library would find it easy to arrange his books under a few headings: some being devoted to history or science; others to theology or philosophy; others to fiction, poetry, and so on. In most cases the placing of a book would present no difficulty; but, as the size of the collection increased, works would be met with which, though devoted to history, were in part fictitious, and many works of fiction would be found to be historical. Novels would be met with, the aim of which is the exemplification of some psychological, physiological, or religious truth; and so with all the other departments. Most of the new books could still be arranged under headings as readily as in a smaller collection, but every increase in the size of the library would render the inosculation of the various departments of literature more apparent, and would increase the need of a catalogue with cross-references. If the librarian did not confine his attention to the books in his library, but studied the history of the growth of literature, its embryology and paleontology, he would find

that departments which are now widely separated were once united, and sprang from a common source. He would find that there had been a time when all history and all theology were poetical, and all poetry historical or theological; that all romance was originally more or less historical, and that all history or science was at first more or less imaginary.

By the study of the less frequent and familiar forms of literature, and by the history of its growth, he would, like the naturalist, learn that his distinctions and classifications are only relative; of great value, indeed, but by no means absolute; but he would not therefore conclude that his groups are not real. He would not conclude that, because some novels are historical, there is no such thing as a history and no such thing as a novel, although he would perceive that they are connected by intermediate forms, and have originated from a common source.

The fact that there is no arbitrary line between the groups of natural objects, between animals and plants for instance, or between two related species of animals, does not prove that the groups themselves have not a real existence. The differences between plants and animals are real, and each group may be defined, but no definition can embrace all the forms of one group, and exclude all of the other, any more than a definition of fiction or of poetry can exclude all historical works.

The things, like the words, are real; but the definiteness of words is very different from the indefiniteness and complexity of Nature.

PROFESSOR TYNDALL BEFORE THE ENGLISH COPYRIGHT COMMISSION.[1]

QUESTION (*Chairman*). I believe you have published not only in England, but in the United States?

Answer. I have published about a dozen volumes in England, and most, if not the whole of them, have been reproduced in the United States.

Q. With your sanction?

A. With my sanction. I make an arrangement with my publishers, the Messrs. Appleton, in New York, and they every year send me an account of their sales, and allow me a certain percentage on the retail price of my books.

Q. Now you have heard, I think, since you have been in this room, the scheme which has been submitted to the consideration of this com-

[1] Tuesday, April 17, 1877: Lord John Manners, M. P., in the chair. Members of the commission present: Sir H. D. Wolff, Sir Julius Benedict, Sir James Stephen, Dr. William Smith.

mission, by which the existing law of copyright would be repealed and the system of royalty established in its place, under which a publisher of the first edition of a new work would have what we may call a close time of a year, and after that it would be open to any other publisher, paying a fixed royalty to the author, to bring out new editions of that work. Have you turned your attention to the probable operation of a scheme of that sort, on the works, for instance, that you yourself have published?

A. I have given it some attention since the subject was first mentioned to me by a member of this commission, and I have listened to the evidence given in this room since I came into it. In that evidence I have heard over and over again beliefs expressed of what would occur if the royalty scheme were to become law. These beliefs are to be pitted against what we now know as certainties; and taking everything into account, I prefer the certainty now known to me to the beliefs expressed by the witness who preceded me. It would be in my opinion a gross injustice, and might open a channel to interference of a still more serious and sweeping character, if the rights of an author over his hard-earned intellectual property were interfered with in the manner I have heard indicated here.

Q. Now under the present law has it been your custom to part with your copyright in the first instance, or only for a limited period?

A. The first work that I ever published was given to an eminent publisher; and I was averse to making any arrangement whatever with him. In those days I thought it in a measure ungentlemanly to bargain or haggle with a publisher; and I left it to him to do what he pleased with the volume. Subsequently, the Messrs. Longman, and particularly Mr. William Longman, pressed me more than once to publish a volume of lectures, and about 1862 I agreed to do so. There was at that time a subject of great and growing importance, regarding which the English public were entirely uninformed, though the public intelligence was raised, I thought, to a sufficient level to profit by a clear exposition. With very hard labor I accomplished a volume on this subject. I felt myself free (and this is the liberty that I should very much object to see limited in any way) to say to Mr. Longman that I should regard him as a business-man; that publishers were, to my knowledge, very competent to take care of themselves, and that I was determined, if he published a volume of mine, also to take care of myself and meet him on business-terms. It was his wish that I should do so, and we then and there entered into an agreement for a single edition of the work. That has been my practice with Messrs. Longman up to the present hour. I sell my books to them edition by edition, always retaining the right to dispose as I please of the subsequent editions of each work. The expenses of each edition—of printing, paper, and advertisements—are added up, the book is priced by mutual agreement, the profits are ascertained, and on the day of publication

I receive a certain proportion of those profits. I do this for the purpose of detaching myself as much as possible from business questions when the work is done.

Q. Under the present law you make your own arrangements for the sale of each edition?

A. I do.

Q. And under the proposed change of the law, as you apprehend it, instead of your having the freedom to do that and make an arrangement on your own terms with your publisher, the law would step in after the first edition and insist upon a certain rate of remuneration being afforded you by any publisher who chose to take your work and publish a new edition of it?

A. That is the impression that I have received of the proposed scheme, and I conceive that nothing can be more unfair. I think it would be simply flagitious to interfere with the rights of an author to that extent.

Q. (*Sir J. Benedict*). Could you imagine any change in the law which you would propose to facilitate the acquirement by the public of works of such a character as you write yourself, or would it be possible to make the agreement such that the price of the books, which now is the great bar to their popularity in the first instance, could be lowered without injury to the author and to the publisher?

A. That is a subject on which at the moment I should not like to offer an opinion. I am here speaking of an author's rights over the produce of his own hard work. I may perhaps refer to a fact that was brought to my mind by the examination of the gentleman who preceded me. I think it perfectly fair for an author, if he thinks fit, to write a work that appeals to the wealthier classes of the community.[1] I wrote a little book some years ago called "Faraday as a Discoverer," in which I gave a sketch of Faraday's life and work. The book was published at 6*s.* or 7*s.*; it is a small book; I gave myself great trouble to write it, and the edition was very soon sold. Many of my friends urged upon me that it was almost a duty for me, and that for the public it would be a boon if a cheap edition of that book were published. It was accordingly published at the price of 3*s.* 6*d.*, but the sale of that book was by no means so rapid or so remunerative as the sale of the dearer one had been.

Q. (*Sir H. D. Wolff*). In regard to that book, will you forgive my asking you, do not you think that the reason why the sale of the cheap edition at 3*s.* 6*d.* was slower than of the edition at 6*s.* was owing to the two prices being rather near each other; there is not that enormous gap between the prices that there is, for instance, between 25*s.* and 6*s.*?

A. That is true; but I should not be inclined to ascribe the slower sale of the cheaper book to the smallness of the gap. I think the first

[1] Mr. Gould, for example, wrote books on birds so sumptuously illustrated, that none but the wealthy could buy them.

book appealed to a highly-intelligent class, that associated with their intelligence the means of purchasing the book, and they did purchase it. Had the book been published in the first instance at 3*s.* 6*d.*, no doubt that same class of buyers would have purchased the book, but it would certainly have been at my personal loss.

Q. Perhaps that may be the case; but if you had published it originally, instead of at 6*s.*, at a higher price, do not you think that probably your sale would not have been as large as it was at 6*s.*?

A. That I cannot say. I always have a conversation with my publisher on these matters, and I defer very much to his knowledge.

Q. But at once by publishing at 6*s.* you addressed yourself to a public who could afford 6*s.*, instead of to a public only who could afford a higher price. Many people could pay 6*s.* who could not pay 12*s.* 6*d.*?

A. I assume authors to possess a certain amount of conscience; and if Mr. Longman had proposed to me to publish that book at 12*s.* 6*d.*, I should have objected to the price. Considering the amount of labor I had invested in the book, I should not have allowed him to publish it at 12*s.* 6*d.*

Q. That is because you are an exceptionally conscientious man perhaps?

A. Speaking for myself, I certainly should have prohibited that.

Q. You mentioned that you considered that the plan that we have been discussing with the last witness would be an interference with your rights. May I ask you exactly to define what you think your rights are? I will tell you why I ask you that; it is this, I want to know whether your rights are rights of remuneration, or rights of control over the publication, that is to say, the type in which it is to be, or the particular form in which it is to be published?

A. I am speaking altogether of rights of remuneration. An illustration occurs at the present moment. I am now engaged on the sixth edition of my book on "Heat," and I really intend to go in a few days to the Messrs. Longman and to say, "I think that, considering your labor and mine, we ought to have another arrangement, and that I ought to receive a higher proportion of the profits than I have hitherto received. You know it is open to me to go to another publisher, and you also know that I shall have no difficulty in obtaining the terms which I now offer to you." I regard it as my undoubted right, considering the labor I have expended on those works, to take them to the best market. If Longman does not give me my terms I should like to have the liberty of going to Macmillan, Chapman & Hall, Mr. Henry King, or Mr. Murray. That is the right I claim.

Q. You stand in a far better position toward Mr. Longman than an unknown man would?

A. I dare say; but I have had to raise myself into that position by very hard work.

Q. You said just now that these were only "beliefs" that we had.

You think that the system now proposed would not act as advantageously as the present system does; that is only putting one belief against the other, is it not?

A. Irrespective of beliefs I object to my liberty of action being interfered with. Even if I felt sure that I should lose nothing by the proposed change, I should still fight for my liberty of action.

Q. Now I am going to ask you a question which you can answer or not, as you like. Are your books published in America at a cheaper rate than they are in England?

A. It will perhaps be best to answer by definite examples. My volume on "Sound" was published at 9*s.* in England, and at 8*s.* 4*d.* in the United States. A little volume entitled "Forms of Water" was published at 5*s.* in this country, and 6*s.* 3*d.* in the States. "Heat" was published at 10*s.* 6*d.* in this country, and at 8*s.* 4*d.* in the States. Considering the price of labor in America, I should have inferred that books there were dearer than here, but on the whole my books appear to be somewhat cheaper in the States than in England. It should not, however, be forgotten that I usually send them stereotyped from my printer here to my publishers in New York, and that some of them have been published in a smaller form in America than here.

Q. May I ask if the percentage that you receive (if it is not a liberty to ask the question) in America on your books is as large as it would be if you had copyright in America, this voluntary percentage that they give you?

A. I cannot say, but I should be inclined to think so, because I am in the hands of a most high-minded publisher. I believe that I should gain no advantage by the copyright in America that I do not possess at present. But though I should be unaffected, on public grounds I hold that a copyright ought to exist.

Q. Then there are illustrations, I suppose, in your books, are there not?

A. Many of them are illustrated.

Q. Do you give them the plates of your illustrations, or do they reproduce them?

A. I send them over the plates of everything. I say, for instance, to Messrs. Longman, "Messrs. Appleton will require stereotyped plates, and also plates of the engravings of this book." The Longmans fix the price of the plates and receive it from the Appletons, and I am saved any further trouble in the matter.

Q. Then you have a greater protection altogether than an ordinary popular writer, inasmuch as in the first place you address yourself to a particular class, which I suppose you do to a certain extent?

A. Yes, undoubtedly.

Q. And in the second place you have the hold over your plates. To pirate your books, supposing they did that against your will, they would have to go to a great expense?

A. No doubt to some extent, but the plates are not of that expensive character that would deter a pirate. My chief safeguards are that the Messrs. Appleton are very powerful publishers, and could afford to undersell a rival, and that there is a kind of tacit understanding among the larger publishers in America that the books published by one should not be pirated by another.

Q. If Messrs. Appleton were not high-minded people they would still have a difficulty in pirating your book, because they would find a difficulty in getting the plates, you having the whole of the plates?

A. Yes; but that would apply equally to other publishers. The plates have to be produced in England and paid for in England, and a book that pays for plates in England would pay for them in America. They could not perhaps produce the books so cheaply as they now do if they had to produce the plates.

Q. Is your circulation larger in America than in England?

A. I could not say so. I have been assured over and over again that it is very large.

Q. I fancy your books are not books much read in circulating libraries; they are more books which people would study, are they not?

A. My first book that related to the Alps and glaciers might have got into the circulating libraries; but I do not remember to have seen any of my more strictly scientific works in them.

Q. (*Dr. Smith.*) We are right then in supposing that you object entirely to the legislature interfering by any enactment with your books, and that you prefer to make your own bargain with your own publisher?

A. I should like to be able to express to you the strength of my objection to any such interference. I hold my right to my own intellectual work to be at least as sacred as is the right of my excellent friend, whose propositions have been discussed here, to Abinger Hall.

DRINKING-WATER FROM AGRICULTURAL LANDS.

By J. A. JUDSON, C. E.,

MEMBER OF THE AMERICAN SOCIETY OF CIVIL ENGINEERS, FELLOW OF THE AMERICAN GEOGRAPHICAL SOCIETY, ETC.

LITTLE as it appears to be appreciated, there is to-day no question of sanitary science of greater vital importance than that of the *quality* of the water-supply entering into the daily domestic economy. The requirements and refinements of modern civilization demand not only a plentiful but a profuse supply of water, and at a moderate cost—facts long ago recognized and acted upon. While enormous capital and the best engineering talent have been very generally called upon, both

in this country and in Europe, to economically furnish water in ample *quantity*, a corresponding degree of skill and enterprise has not always been directed to the determination of its *quality*.

It is not impossible to point out authorities on sanitary matters so wedded to pet theories that they unhesitatingly deny that the conversion of a pure running stream, or even a large river, into a conduit for the sewage-filth of a great city, will have any deleterious effect on the potable quality of the water taken a few miles below the filth-entering point. It has been demonstrated that this is not only false in theory but also in fact. It was Dr. Letheby, of the English "Royal Commission on the Water-Supply of London," it is believed, who was the first to announce what has since been proved a fallacy, viz., that "if sewage be mixed with twenty times its volume of river-water, the organic matter which it contains will be oxidized and completely disappear while the river is flowing a dozen miles or so;" and further, that "it is safe to drink sewage-contaminated water after filtration." The "Royal Rivers Pollution Commission" of 1868, unwilling that this expression of opinion should remain untested, submitted it to careful and ingenious experimental investigation. The result is thus announced: . . . "It is thus evident that so far from sewage mixed with twenty times its volume of water being oxidized during a flow of ten or twelve miles, scarcely two-thirds of it would be so destroyed in a flow of one hundred and sixty-eight miles, at the rate of one mile per hour, or after the lapse of a week." And, after mentioning certain details in support of this, the commissioners conclude with the remark that "it will be safe to infer, however, from the above results, that there is no river in the United Kingdom long enough to effect the destruction of sewage by oxidation." Dr. Frankland, an eminent English authority, before the Royal Commission on Water-Supply, gives some strong testimony in support of the statement that it is impossible to remove the sewage-contamination from water by any known process, natural or artificial, so as to render it harmless, except by boiling for a long time, or by distillation; and, as these two processes are impracticable on a large scale, then, he says, in his opinion, "water that has once been contaminated by sewage ought not afterward to be used for domestic purposes; and, inasmuch as it is generally believed that the noxious matter of sewage exists there in the form of minute germs, which are probably smaller than blood-globules, I do not believe that even filtration through a stratum of chalk could be relied upon to free the water perfectly from such germs." According to the same authority, "the noxious part in sewage is that which is held in mechanical suspension, not held in solution;" and yet, he says, and truly, "no system of filtration will secure its removal." Colonel J. W. Adams, C. E., in a valuable paper on river-pollution,[1] follows up this subject to its logical con-

[1] "Report on Water-Supply for the City of Philadelphia," made by a commission of engineers in 1875.

clusions. Dr. Folsom, in the "Report of the State Board of Health of Massachusetts for 1876," also attacks this branch of the question, remarking that "excessive dilution simply *diminishes* the chances of danger from any particular tumblerful." He here states a case of transmission of disease in dilute sewage, to which special attention is invited, as showing quite conclusively the fatal result ensuing from reposing too great faith in the extermination of disease-germs by oxidation, and of reducing the chances of transmitted disease by diffusion of disease-germs through a large body of running water. Dr. Folsom says: "The most striking case illustrating this law is one reported by Dr. E. D. Mapother, of Dublin. Forty cases of typhoid fever occurred in a hospital which received its supply from a river. The cause was traced to some barracks *twenty-five miles* higher up, from which typhoidal dejections had been emptied through drains into the river."

It would be easy to multiply authorities on this point. Suffice it to say that this pernicious theory is happily exploded, and that the Second English Rivers Pollution Commission publish conclusions, based on the examination of some two thousand samples of water claimed to be drinkable, condemning river-water because it is liable to contamination from *drainage of cultivated land*, towns, and manufactories. They state that "the admixture of even a small quantity of these infected discharges (of persons suffering from cholera or typhoid fever) with a large volume of drinking-water, is sufficient for the propagation of those diseases among persons using such water." The case related by Dr. Folsom, previously quoted, as well as numberless others of a similar sort, proves the accuracy of this conclusion.

The English commissioners then classify potable waters as follows, and, when we consider the high authority for this scale of wholesomeness, it would seem that it should carry great weight with it. Though often published before, it cannot be too frequently repeated:

WHOLESOME.	1. Spring-water. 2. Deep-well water. 3. Upland surface-water. (Very palatable.)
SUSPICIOUS.	4. Stored rain-water. 5. Surface-water from cultivated land. (Moderately palatable.)
DANGEROUS.	6. River-water to which sewage gets access. 7. Shallow-well water.

While wholesale river-pollution from any source is utterly inadmissible on any sanitary grounds, so infinitesimal pollution by dilute sewage, indirectly discharged into the water-course, is equally dangerous, and attended with *sure* though more remote fatal results, "*especially if human excreta be present in any form whatever.*" The whole subject is intimately connected, but it is to this latter point more particularly that this paper leads, as touching the pollution of entire

water-basins through the application of organic manure to their gathering-surfaces, for agricultural purposes, and the consequent pollution of the water derived therefrom.

It is well known that many years ago the pollution of the water-courses began to excite public attention in England, and the labors of the several "Rivers Pollution Commissions," and other sanitary committees organized by authority of Parliament, bear testimony in their elaborate and invaluable reports to the truth that humanity can no longer afford to ignore that foul water will breed disease. The dense population of England, and the resultant mass of concentrated filth, have there compelled attention to those laws of health that we, with our enormous area of comparatively thinly-settled country, and the consequent high dilution of foul water and foul air, have felt safe in disregarding. This feeling of safety is, however, fallacious; for, as facts attest, "filth-diseases" are as liable to break out in an isolated house as in a crowded city, if the fundamental hygienic laws are violated. The distinguished labors of the State Board of Health of Massachusetts, as well as those of various other similar boards, bring the subject home to us in a forcible manner, and the sooner we know what sort of water we are drinking the better for us and for those who succeed us.

As fair water is at once a prime necessity and a priceless blessing, so foul water is a scourge and curse; nor will any but a sewage-rectifying enthusiast hesitate for an instant which to choose, provided he has the means of knowing one from the other. Gross pollution is sensible to the sight, the taste, the smell, and we instinctively revolt; lesser pollution, though perhaps not apparent to any of the senses, yields its secret to the chemist's skill; while infinitesimal pollution eludes all, even the art of the chemist himself, revealing its presence only in its fatal effects, the mortality statistics proving the presence of that subtile poison chemical analysis is powerless to detect. Special stress should be laid on this latter point, because the popular cry generally is, where water is suspected, "Let's have it analyzed!" whereas the truth is, beyond a certain point, the chemist can tell us nothing at all about it. Sir Benjamin Brodie, in speaking of the detection of infinitesimal pollution, says: ". . . I think you have a much better chance of getting at these relations through accurate medical statistics, properly applied, than you have through chemical analysis, because chemical analysis is one of the poorest things possible to reach those delicate quantities. You cannot get at those small quantities at all; chemical analysis must be limited by our power of weighing and measuring. We can only do those two things. We can weigh and we can measure, and we can do that with certain accuracy, and there we stop; but that accuracy is not capable of being multiplied *ad infinitum*. It may go on to a certain point, but we cannot go beyond that point."

Having once determined in what pollution consists, then any suspicious water should be unhesitatingly condemned. Colonel Adams

says (in the paper previously quoted), "Grounds for *distrust* in determining the purity of water are grounds for its rejection, especially when brought into comparison with water from a source of undoubted purity."

It has been objected that no water outside the laboratory is absolutely "pure;" that water ordinarily available for town-supply is only *relatively* pure, and that too high a degree of purity must not be expected, lest the *cost* of the works be too great a public burden. This is true, abstractly, yet who will have the temerity to draw the line and say: "Our town can and must stand such and such a death-rate, but no more; let us risk it and take our water from this contaminated pond close by, and let the death-rate be so and so, rather than spend so many thousands more in bringing pure living water from the everlasting hills miles away, and thus reduce our death-rate to the minimum!"

The question of cost should never for a moment weigh against the question of purity of quality. Foul, though apparently pure, water may be the cheaper in the beginning, but it will surely be the dearer to the community in the end, when it is remembered that health and life itself tremble in the balance. Cost and quantity should not be underrated, certainly, neither should quality. It is the frequent neglect of this latter element of calculation, in designing works for the water-supply of towns, that results in the frightful epidemics usually and impiously attributed to the "mysterious dispensations of Providence," rather than to human ignorance, or cupidity, or negligence. Recently an English clergyman actually preached to his parishioners that a devastating fever among them was a visitation from God upon them in punishment for their sins, while at the same time a gentleman, writing to the authorities to complain of the water-supply, dipped his pen in, and wrote with water from the river instead of ink!

Setting aside now all other sources of water-contamination, let us see what the best authorities say would be the effect on the quality of drinking-water derived from agricultural lands enriched with organic manures, and especially that manure which consists largely of human excreta from privy-vaults and the contents of house cesspools.

Two propositions may here be stated that are perfectly sustained by proof:

1. *Any organic matter* will poison water, and is not removable except by boiling or distillation.

2. *Human excremental matter* is the most dangerous organic substance likely to be contained in privy-vaults or cesspools, and its virulence is largely increased when it consists partly of the excrementitious matter of cholera and fever patients.

We will take as an example a compactly-built town of some fifteen thousand inhabitants. Each habitation has its one or more privy-

vaults and cesspools, some of which overflow into the few rude sewers built without any systematic plan, and themselves but "elongated cesspools," or, as some one pertinently calls them, "retorts for the generation of poisonous gases." A large majority of these sinks of abominations have no communication with any sort of sewer, but after prolonged conservation, resulting in horrible putrefaction, when no longer tolerable, are finally emptied by hand into carts and hauled away. Adjoining the town is the gathering-ground of the water-works of thousands of acres in extent, whose waters, discharged into running streams in a long valley, are collected and retained in a dammed-up pond at the foot, and pumped to the distributing reservoir on a neighboring hill. Water-works and sewerage systems should go hand-in-hand; but in this case there is no connection—the latter, indeed, existing only in name. Even this state of things might be tolerable, were it not that, in addition to poisoning the air and the already supersaturated soil, the contents of these vaults are now directly employed to pollute the water-supply. Destitute of any official control, probably more than one-half of the accumulated town filth is annually spread bodily, spring and fall, over a large part of the water-shedding surfaces. The tank-carts employed are at all hours of the day filled at the doorways of the houses, and shamelessly hauled through the public streets, jolting and slopping their foul contents, marking their route by a train of filth on the roadway, while a column of stench in the air, that lingers long after the pestilence-breeding ox-cart has lumbered away in the distance, proclaims adherence to the practices of the dark ages, and defiance to the rules of decency and the laws of health. A century ago, when there was no generally-known method of deodorizing sewage or decently removing it, this sort of thing had to be done, perhaps, but it instinctively sought the cover of nightfall (as the very term "night-soil" implies); but in this incredible case, in the last quarter of the brilliant nineteenth century, in the midst of a civilized community, there is no attempt to disguise the abominable fact!

The water-slopes are thus heavily manured. What is the result? We shall see.

These farms are very rich and valuable, made so at the expense of the water they shed for domestic use. But this sort of fertilizing must not be confounded with what is known as "sewage-farming," a system of *irrigation* which is declared by the highest authorities to be the best, cheapest, safest, and most inoffensive mode of disposing of all excrementitious and other waste matter, "*provided* its effluent water does not get into the domestic water-supply." The scope of this article will not admit even a brief description of this mode of *irrigation* (not manuring), with its appliances of brick, concrete, and earthenware conduits, its valves and sluice-boards, and its trained and careful administrative corps of workmen efficiently supervised. Those interested in this subject (and which is a side-issue here) can consult the "Conditions of

Sewage-Farming" as stated by the First Rivers Pollution Commission of England, and reprinted, with much other valuable information appertaining, in the "Report of the Massachusetts State Board of Health for 1876" (pages 276–408), in a paper by Dr. C. F. Folsom, on "The Disposal of Sewage." Many modes of "disposal" are herein described, but such "disposal" as this—sowing pestilence broadcast—was never contemplated by any one. Of course it can be *prevented*, but it is not proposed to discuss that matter now.

Now, these organically manured slopes are, many of them, very steep, varying, by actual measurement, from one in seven to one in fifty, and flatter. When the heavy rains of spring and fall occur, the effluent water from those slopes is dilute sewage, dilute human excrement, and, especially if the land has been recently ploughed, a large quantity of the surface-soil, and with it the freshly-applied *human excreta*, and the remaining noxious parts of the previously-applied batch of filth still present in the soil, must necessarily be, and is, washed down-hill and into the water-supply of the town. The English scientific periodical *Engineering* records that, early in the spring of 1876, "the piers of Vauxhall Bridge were coated with a covering of upward of a foot deep of soil, brought down from the upper portion of the Thames during one tide, and this minor instance is but a slight indication of the enormous deposits cast into our (British) rivers through the washing of the surface-soil from the adjacent fields. . . . The water, before being drawn into the Thames companies' reservoirs, was loaded consequently with soil, manure, sewage, and every imaginable abomination that newly ploughed and manured fields and towns could supply."

Of course, this pollution was on a larger scale than could occur in the case here treated. Nevertheless, if the quantity of polluting matter be less, so is the volume of water polluted, hence the proportion of foulment may be approximately the same. At any rate the fact remains that the water is contaminated, and, as has been already shown, infinitesimal may be quite as fatal as profuse pollution.

The elements that go to make dilute sewage unfit for assimilation in man, especially fit it for plant-food, a fact well known to every gardener. Dr. Folsom says that "a celebrated horticulturist in Brighton, England, dilutes his manure until it has neither taste nor smell." If such attenuated "barn-yard coffee" can have manurial effect on vegetation, what physiological effect—pathologic and hygienic—would it be likely to have when employed as a beverage? This very question is answered in a report to the English "General Board of Health" in 1856, the substance of which is as follows: ". . . It is now generally admitted that the substances which constitute the organic matter of water act injuriously, by no means (necessarily) in consequence of being poisonous themselves, but by undergoing those great processes of transformation called decay and putrefaction, to which all vegetable and animal matter is subject, when no longer under the control of vi-

tality, either in plants or animals. These putrefactive processes either give rise to the formation of poisonous bodies, or they act simply as ferments, generating similar processes of decomposition in the substances composing the animal organism."

The "controlling vitality" of plants and man have widely differing requirements: what is food to one is to the other poison, and sewage-polluted water is just what the Brighton gardener uses.

Dr. Corfield says, in a lecture before the Royal School of Military Engineering at Chatham, that ". . . mere passage *over* the soil will not purify sewage satisfactorily. The effluent water which goes off the land is, to all intents and purposes, *sewage*." And Mr. Denton, a distinguished engineer and scientist, says, in a lecture before the same school, that ". . . water collected from the surface of cultivated lands, and from the under-drains of cultivated lands, is always more or less polluted with the organic matter of manure, *even after subsidence in lakes or reservoirs*." Shallow-well water is declared by the Rivers Pollution Commissioners to be the most dangerous of all waters, "whenever the wells are situated, as is usually the case, near privies, drains, and cesspools;" and it is this shallow-well water that Denton refers to when he goes on to say the commissioners declare that "such polluted surface or drainage water (referred to above) is not of good quality for domestic purposes, but it *may* be used with less risk to health than polluted shallow-well water, if human excrementitious matters do not form part of the manure applied to the land." Mark this, on the highest authority, that shallow-well water, the most dangerous stored well-water known, is safer to drink than the effluent water from such slopes as this article describes. When it is added that the Royal Commissioners, having examined the waters of some four hundred and twelve shallow wells in different geological formations, pronounce them all, with few exceptions, "entirely unfit for human consumption," the force of the objections raised against the water from the foul slopes may be appreciated.

It may be suggested that filtering be resorted to, or the sewage "disinfected," as some are pleased to call certain processes. But the English commissioners say that "as applied to sewage, disinfectants do not disinfect, and filter-beds do not filter. Both attempts have been costly failures." And again they say, "No process has yet been devised of cleansing surface-water once contaminated with sewage, so as to make it safe for drinking." To this the late Mr. Kirkwood, the distinguished American engineer, adds, ". . . If this view of the case may seem to be over-cautious, it is to be remembered that the poison, however trifling, is taken daily, and that, although when in robust health the individual will not suffer from it, it may be sufficient to make itself felt when he is prostrated by sickness, and his powers of resistance to such influences are then proportionally impaired."

It has been supposed that if the sewage be applied to these slopes

while the ground is frozen, the greater part, at least, will percolate into the earth, owing to the higher temperature of the sewage and the heat disengaged by continued fermentation, and so be out of harm's way before the advent of the thaws and rains of spring. It has been proved by experiments in Maine, with the thermometer at 0° Fahr., that the sewage disappears soon after it is applied. It would be safer, no doubt, but the "brown scum," which, it is said, remains on the surface, would be thrown down by the spring rains, and other poisonous matter would follow as soon as the plough broke the surface. The danger might, perhaps, be diminished, as in the case of dilution in running water—nothing more.

Too much stress cannot be laid on the death lurking in all manner of human excreta, especially those of the sick. Dr. Folsom, the Secretary of the Massachusetts State Board of Health, and one of the first sanitary authorities, says: "In no case is it entirely safe to drink water which has once been contaminated with human excreta containing the germs of disease, unless it has been exposed to a sufficiently high temperature or has stood long enough for these 'germs' to become inert. How long this time must be, we do not yet know." And again he says that, "under certain conditions, human excrementitious matter in certain diseases is almost certain poison, producing the parent-disease in great numbers of cases of those exposed to it, with a degree of virulence proportional to its concentration."

The cases on record sustaining this are numerous; two very striking ones must suffice here:

Colonel George E. Waring, Jr., in his "Sanitary Drainage of Houses and Towns," relates the case of an outbreak of "filth-fever" in Over-Darwin, England, a few years ago. "The first case," he says, "was an important one, occurring in a house some distance from the town. The patient had contracted the disease, came home, and died with it. . . . The drain of the closet used by this patient emptied itself through the irrigating channels of a neighboring field. The water-main of this town passed through this field, and, although special precautions had been taken to prevent any infiltration of sewage into the main, it was found that the concrete had sprung a leak, and allowed the contents of the drain to be sucked freely into the water-pipe. The poison was regularly thrown down the drain, and as regularly passed into the water-main of the town. . . . Within a short period 2,035 people were attacked, and 104 died."

The "Massachusetts State Board of Health Report for 1877" records an epidemic of typhoid fever which occurred at Eagley, in England, in 1876. The report says: "A certain small brook had been used by the operatives of a mill, so that 'large quantities of fecal matter' were found on its banks and in its bed. It was known, too, that one of the workmen was ill (it was thought that there was a possibility of the disease being typhoid fever). This brook had formerly been used, two

hundred yards below, for domestic purposes, but had generally been abandoned since it had become impure, although two families continued to use it, of whom one had typhoid fever, and the other (who boiled it before use) escaped. This same water continued to be used at a *dairy*, and was the only supply there. Although there is no positive evidence that the milk was diluted with it, it was acknowledged that the milk-cans were washed in it.

"From January 30th . . . . to February 15th, 146 persons were attacked, when the epidemic declined."

After giving further details it is stated that in the town of Bolton, two miles distant, "there were fifty families attacked, of whom forty-seven were supplied with milk from this same dairy." The investigating officer reported that "not one household to which the milk was traced did he find entirely free from the disease."

Liebermeister, an eminent authority, says, speaking of the spread of typhoid fever through water-works: "Such infection of an aqueduct is most easily effected when excrements from privies containing the typhoid poison are used as manure on the fields from which the aqueduct receives its supply. In this way originated the epidemic in Stuttgart in the year 1872."

Aside from the water we take into our stomachs, sanitation and sentiment alike demand that it should be wholesome. Denton says: "The water used for personal ablution, and for the washing of the clothes we wear, and the utensils we use in cooking, have a material though not so direct an influence on our sanitary condition." The milk-can case had not occurred when this was written, for, if that be true, he might have put it still stronger.

We can safely conclude that it is the *quality* of the sewage-matter that determines the character and virulence of its poisonous effects, rather than the *quantity* of foul matter that may be present in the drinking-water, the taint from the fecal matter of one sick person creating wider-spread havoc than that from hundreds of those "that need no physician."

Long before the milk-can case occurred, the English commissioners said that "really there is no reason whatever to believe that the injurious character of sewage depends, fundamentally, upon the *quantity* of that sewage; in all probability it far more depends upon the *quality* of the sewage, namely, what it consists of."

As people generally have a vague idea of what sewage consists, any further than that it is a nasty mess, it may be well, in closing this article, to give the definition of the term "sewage" as applied by the English Rivers Pollution Commissioners. It is "any refuse from human habitations that may affect the public health. . . . Sewage is a very complex liquid; a large proportion of its most offensive matters is, of course, human excrement discharged from water-closets and privies, and also urine thrown down gully-holes. But mixed with this

there is the water from kitchens containing vegetable, animal, and other refuse, and that from wash-houses containing soap and the animal matter from soiled linen. There is also the drainage from stables and cow-houses, and that from slaughter-houses containing animal and vegetable offal. In cases where privies and cesspools are used instead of water-closets, or these are not connected with sewers, there is a still larger proportion of human refuse in the form of chamber-slops and urine. In fact, sewage cannot be looked upon as composed solely of human excrement diluted with water, but as water mixed with a vast variety of matters, some held in suspension, some in solution." In fact, were we to fall into the habit of looking upon it and calling it *poison*, instead of *sewage*, and treating it as we do any other poison, one step, at least, will have been taken on the high-road to safety. Surely no civilized community ought knowingly to use water polluted, no matter in what degree, with such filth as this.

Denton says that from the report on the "Army and Navy Diet Scales" he finds that "the estimated quantity of liquid of all kinds drunk in the two services averages 187½ gallons per head per annum, or about two quarts per day. Though this quantity is drunk by adults of the male sex, it is some criterion of the quantity drunk by men, women, and children, and it will not be wrong to assume that two-thirds, or 125 gallons per head, is as much as is actually consumed by a mixed population in a year. Dr. Parkes says that an adult requires daily from seventy to one hundred ounces (three and a half to five pints) for nutrition, but about twenty to thirty ounces of this quantity are sometimes in the solid food." This is what we daily put in our mouths, and it certainly should be pure and sweet. In fact, one way or another, we are pretty much all water. It is said that "the model man weighs 154 pounds, of which 116 is water and only 38 pounds dry matter;" based on which fact, Edmond About has written a curious romance, "The Man with the Broken Ear." Water, then, is of all things the one most essential to our existence, and if three-quarters of our very bodies and a large part of our daily food are composed of this element, then, like Cæsar's wife, it should be "clear even of suspicion."

Although, perhaps, there is no special occasion for it in this connection, attention is invited, in the interest of accuracy, to the popular misuse of the term "water-shed." It is ordinarily employed to denote the area collecting the rainfall, and comprised between the highest and lowest points. Properly speaking, a "water-shed" is "the anticlinal ridge separating one river-basin from another." The highest crest-line of a ridge, therefore, is the *water-shed;* the lowest area in the valley up to the highest water-level is the *water-basin;* while the area between these (miscalled the water-shed) may be termed the "gathering-ground," or the "collecting slopes."

EDUCATION AS A SCIENCE.

By ALEXANDER BAIN, LL. D.,
PROFESSOR IN THE UNIVERSITY OF ABERDEEN.

VI.—THE EMOTIONS IN EDUCATION (*continued*).

I NOW proceed with the review of the Emotions as motives in education.

Play of the Emotions of Activity.—Nothing is more frequently prescribed in education than to foster the pupils' own activity, to put them in the way of discovering facts and principles for themselves. This position needs to be carefully surveyed.

There is, in the human system, a certain spontaneity of action, the result of central energy, independent of any feelings that may accompany the exercise. It is great in children; and it marks special individuals, who are said to possess the active temperament. It distinguishes races and nationalities of human beings, and is illustrated in the differences among the animal tribes; it also varies with general bodily vigor. This activity would burst out and discharge itself in some form of exertion, whether useful or useless, even if the result were perfectly indifferent as regards pleasure or pain. We usually endeavor to turn it to account by giving it a profitable direction, instead of letting it run to waste or something worse. It expends itself in a longer or shorter time, but while any portion remains, exertion is not burdensome.

Although the spontaneous flow of activity is best displayed and most intelligible in the department of muscular exercise, it applies also to the senses and the nerves, and comprises mental action as well as bodily. The intellectual strain of attention, of volition, of memory, and of thought, proceeds to a certain length by mere fullness of power, after rest and renovation; and may be counted on to this extent as involving nothing essentially toilsome. Here, too, a good direction is all that is wanted to make a profitable result.

The activity thus assumed as independent of feeling is nevertheless accompanied with feeling, and that feeling is essentially pleasurable: the pleasure being greatest at first. The presence of pleasure is the standing motive to action; and all the natural activity of the system—whether muscular or nervous—brings an effluence of pleasure, until a certain point of depletion is arrived at.

If, further, our activity is employed productively, or in yielding any gratification beyond the mere exercise, this is so much added to the pleasures of action. If, besides the delight of intellectual exercise, we obtain for ourselves the gratification of fresh knowledge, we seem to attain the full pleasure due to the employment of the intellect.

Much more, however, is meant by the gratification of the self-activity of the learner. That expression points to the acquiring of knowledge, as little as possible by direct communication, and as much as possible by the mind's own exertion in working it out from the raw materials. We are to place the pupil as nearly as may be in the track of the first discoverer, and thus impart the stimulus of invention, with the accompanying outburst of self-gratulation and triumph. This bold fiction is sometimes put forward as one of the regular arts of the teacher; but I should prefer to consider it as an extraordinary device admissible only on peculiar occasions.

It is an obvious defect in teaching to keep continually lecturing pupils, without asking them in turn to reproduce and apply what is said. This is no doubt a sin against the pupil's self-activity, but rather in the manner than in the fact. Listening and imbibing constitute a mode of activity; only it may be overdone in being out of proportion to the other exercises requisite for fixing our knowledge. When these other activities are fairly plied, the pupil may have a certain complacent satisfaction in his or her own efficiency as a learner, and this is a fair and legitimate reward to an apt pupil. It does not assume any independent self-sufficiency; it merely supposes an adequate comprehension and a faithful reproduction of the knowledge communicated. The praise or approbation of the master, and of others interested, is a superadded reward.

Notwithstanding, there still remains, if we could command it, a tenfold power in the feeling of origination, invention, or creation; but as this can hardly ever be actual, the suggestion is to give it in fiction or imagination. Now, it is one of the delicate arts of an accomplished instructor to lay before his pupils a set of facts pointing to a conclusion, and leave them to draw the conclusion for themselves. Exactly to hit the mean between a leap too small to have any merit, and one too wide for the ordinary pupil, is a fine adjustment and a great success. All this, however, belongs to the occasional luxuries, the *bonbons*, of teaching, and cannot be included under the daily routine.

It is to be borne in mind that although the pride of origination is a motive of extraordinary power, and in some minds surpasses every other motive, and has a great charm even in a fictitious example, yet it is not in all minds the only extraneous motive that may aid the teacher. There is a counter-motive of sympathy, affection, and admiration, for superior wisdom, that operates in the other direction; giving a zest in receiving and imbibing to the letter what is imparted, and jealously restraining any independent exercise of judgment such as would share the credit with the instructor. This tendency is no doubt liable to run into slavishness, and to favor the perpetuation of error and the stagnation of the human mind; but a certain measure of it is only becoming the attitude of a learner. It accompanies a proper sense of what is the fact, namely, that the learner *is* a learner, and not a teacher or a discov-

erer, and has to receive a great deal with mere passive acquiescence, before venturing to suggest any improvements. Unreasoning blind faith is indispensable in beginning any art or science; the pupil has to lay up a stock of notions before having any materials for discovery or origination. There is a right moment for relaxing this attitude, and assuming the exercise of independence; but it has scarcely arrived while the schoolmaster is still at work. Even in the higher walks of university teaching, independence is premature, unless in some exceptional minds, and the attempt to proceed upon it, and to invite the free criticism of pupils, does not appear ever to have been very fruitful.[1]

Play of the Emotions of Fine Art.—This is necessarily a wide subject, but for our purpose a few select points will be enough. The proper and principal end of art is enjoyment; now, whatever is able to contribute on the great scale to our pleasure, is a power over all that we do. The bearings on education are to be seen.

The art-emotions are seldom looked upon as a mere source of enjoyment. They are apt to be regarded in preference as a moral power, and an aid to education at every point. Nevertheless, we should commence with recognizing in them a means of pleasure as such, a pure hedonic factor, in which capacity they are a final end. Their function in intellectual education is the function of all pleasure when not too great, namely, to cheer, refresh, and encourage us in our work.

There are certain general effects of art that come in well at the very beginning. Such are symmetry, order, rhythm, and simple design and proportion; which are the adjuncts of the school, just as they should be the adjuncts of home-life. Proportion, simple design, a certain amount of color, are the suitable elements of the school interior; to which are added tidiness, neatness, and arrangement, among the pupils themselves; only this must not be worrying and oppressive.

In the exercise suited to infants, time and rhythm are largely employed.

Of all the fine arts, the most available, universal, and influential, is music. This is perhaps the most unexceptionable as well as the cheapest of human pleasures. It has been seized upon with avidity by the human

[1] It would lead us too far, although it might not be uninstructive, to reflect upon the evil side of this fondness for giving a new and self-suggested cast to all received knowledge. It introduces change for the mere sake of change, and never lets well alone. It multiplies variations of form and phraseology for expressing the same facts, and so renders all subjects more perplexed than they need be; not to speak of controverting what is established, because it is established, and allowing nothing ever to settle. Owing to a dread of the feverish love of change, certain works that have accidentally received an ascendency, such as the "Elements" of Euclid, are retained notwithstanding their imperfections. The acquiescent multitude of minds regard this as a less evil than letting loose the men of action and revolution to vie with each other in distracting alterations, while there is no judicial power to hold the balance. It is a received maxim in the tactics of legislation that no scheme, however well matured, can pass a popular body without amendment; it is not in collective human nature to accept anything *simpliciter*, without having a finger in the pie.

race in all times; so much so that we wonder how life could ever have been passed without it. In the earlier stages it was united with poetry, and the poetical element was of equal power with the musical accompaniment, if not of greater. As the ethical instructors of mankind have always disavowed the pursuit of pleasure as such, and allowed it only as subsidiary to morality and social duty, the question with legislators has been what form of music is best calculated to educe the moral virtues and the nobler characteristics of the mind. It was this view that entered into the speculative social constructions of Plato and Aristotle. Now, undoubtedly the various modes of music operate very differently on the mind: every one knows the extremes of martial and ecclesiastical music; and fancy can insert many intermediate grades.[1]

For the moment, a musical strain exerts immense power over the mind, to animate, to encourage, to soothe, and to console. But the facts do not bear us out in attributing to it any permanent moral influence; nothing is more fugitive than the excitement of a musical performance. Excepting its value as a substantive contribution to the enjoyment of life, I am not able to affirm that it has any influence on education, whether moral or intellectual. Certainly, if it has any effect in the moral sphere, it has none that I can trace in the sphere of intellect. As a recreative variety in the midst of toil, it deserves every encomium. In those exercises that are half recreative, half educational, as drill and gymnastic, the accompaniment of a band is most stimulating. In the Kindergarten it is well brought in, as the wind-up to the morning's work. But music during ordinary lessons, or any sort of intellectual work, is mere distraction, as every one knows from the experience of street bands and organs.

Excess in the pleasures of music, like every other excess, is unfavorable to mental culture. But some of the most intellectual men that ever lived have been devotees of music. In the case of Luther it seems to have been incorporated with his whole being; Milton invoked it as an aid in poetic inspiration. These were men whose genius largely involved their emotions. But the musical enthusiasm of Jeremy Bentham could have no bearing on his work, further than as so much enjoyment.

Poetry is music and a great deal more. Its bearings are more numerous and complicated. In the ruder stages of music, when it accompanied poetry, the main effects lay in the poetry. The poetic form —the rhythm and the metre—impresses the ear, and is an aid to mem-

[1] Plato, in the "Republic," wishing to train a vigorous and hardy race, interdicted not simply the unfavorable musical strains, but the instruments most adapted to these. He permits only the lyre and the harp, with the Pan's pipe for shepherds attending their flocks; forbidding both the flute and all complicated stringed instruments. Disallowing the lugubrious, passionate, soft, and convivial modes of music, he tolerates none but the Dorian and the Phrygian, suitable to a sober, resolute, courageous frame of mind; to which also the rhythm and movement of the body are to be adapted (Grote's "Plato," iii., 196).

ory ; whence it has been transferred from the proper themes of poetry to very prosaic subjects by way of a mnemonic device. The subject-matter of poetry comprises the stirring narrative, which is an enormous power in human life, and the earliest intellectual stimulus in education.

Play of the Ethical Emotions.—The feelings called ethical, or moral, from their very meaning, are the support of all good and right conduct. The other emotions may be made to point to this end, but they may also work in the opposite direction.

When the educator describes these in more precise and equivalent phraseology, he generally singles out regard to pleasure and displeasure of parents and superiors, together with habits or dispositions toward obedience; all of which is the result of culture and growth.

Any primitive feelings conspiring toward good conduct must be of the nature of the sympathies or social yearnings ; which are called into exercise in definite ways, well known to all students of human nature. By far the most powerful stimulus to acts of goodness toward others is good conduct on their side ; whoever can resist this is a fit subject for the government of fear and nothing else. The law says, "Do unto others as ye *would* that they should do unto you." The lower ground of practice is, "Do unto others as they do unto you." This is as far as the very young can reach in moral virtue.

It is too much to expect in early years generous and disinterested impulses, unreciprocated. The young have little to call their own; they have no means. Their fortune is their free, unrestrained vivacity, their elation, and their hopes. If they freely give up any part of this, it is in consideration of equivalent benefits. They are susceptible of being worked up to moments of self-renunciation, in which they may commit their future irrevocably, without knowing what they are about. But they cannot be counted on for daily, persistent self-restraint, willingly encountered, unless there be some seen reward, present or in the distance. It takes a good deal to bring any one even up to the point of fair and full reciprocity of services in all things.

The Feelings as appealed to in Discipline.—The survey that has now been made of the sensibilities of the human mind available as motives, prepares for the consideration of discipline in teaching. The instructor finds that, in school moments and for school purposes, he has to restrain all the unruly impulses and to overbear the sluggishness of the youthful nature. To succeed in this requirement, many arts are employed, corresponding to the wide compass of sensations and emotions that agitate the human breast.

The question how to maintain discipline among masses of human beings is of very wide application, and is therefore the subject of a great variety of experiments. In the wide field of moral control, it includes a principal function of government, namely, the repression of crime—a department that has lately received much attention. To collect the lights furnished in each of the spheres where moral control has

to be exercised, is to contribute to the illumination of each. There has, undoubtedly, in former times been very great mismanagement in almost every one of the regions of repressive authority—in the state, in the family, and in the school, in all which an excess of human misery is habitually engendered by badness in the manner of exercising control. It is perhaps in the family that the mischief is most widely spread and most baneful.

By degrees we have become aware of various errors that ran through the former methods of discipline, in the several institutions of the state, as well as in the family. We have discovered the evil of working by fear alone, and still more by fear of coarse, painful, and degrading inflictions. We have discovered that occasions of offense can be avoided by a variety of salutary arrangements, such as to check the very disposition to unruly conduct. We consider that a great discovery has been made in regard to punishments, by the enunciation of the maxim that certainty is more important than severity; to which should be added, proportion to the offense. We also consider that by a suitable training, or education, the dispositions that lead to disorder and crime can be checked in the bud; and that, until there has been room for such training to operate, the mind should not be exposed to temptation. We have become accustomed to lay more stress in cultivating the amicable relations of human beings, all which tend to abridge the sphere of injurious conduct on the part of individuals.

The consideration of discipline in education supposes the relation of a teacher to a class, one man or woman exercising over a body of pupils the authority requisite for the work in hand. Nevertheless, it is not lost time to advert, in the first instance, to the maxims pertaining to authority in general.

Authority, government, power over others, is not an end in itself; it is but a means. Further, its operation is an evil; it seriously abates human happiness. The restraint upon free agency, the infliction of pain on individuals, the setting up a reign of terror—all this is justified solely by the prevention of evils out of all proportion to the misery that it inflicts. This might seem self-evident, but is not so. The deep-seated malevolence and lust of domination in the human mind makes the necessity of government a pretext for excesses in severity and repression; to which must be added the opportunity of preying upon the substance of the governed.

Mankind have had their eyes gradually opened to this state of things; the philosophy of society now endeavors to formulate the limits to authority, and to the employment of repressive severities. Not only is it restricted to the mildest penalties that will answer its purpose, but its very existence has to be justified in each case.

Authority is not necessary to every teaching relation. A willing pupil, coming up to a master to be taught, is not entering into a relationship of authority; it is a mere voluntary compact, terminable at

the pleasure of each. There is no more authority over the assemblies of grown men to hear lectures than over the worshipers at church or the frequenters of the play. There is nothing but the observance of mutual toleration and forbearance so far as requisite to the common good; if this were grossly violated, there would be an exercise of power either by the collective mass themselves, or by summoning the constable to their aid. No authority is lodged in the lecturer, preacher, or performer, to repress disturbances.

Authority first appears in the family, and is thence transferred with modifications to the school. It is between these two institutions that the comparison is most suggestive. The parent's authority is associated with sustenance, and has an almost unlimited range; it is tempered by affection, but this depends upon mutuality of pleasure-giving, and supposes a limited number. The teacher's authority has nothing to do with sustenance; his is a duty undertaken for payment; it is subsidiary to the single object of teaching a definite amount of knowledge; it wants the requisites of affection; the numbers are too great, and the mutual concern too restricted. But affection is not wholly excluded, and in certain well-marked cases it may play a part.

On the other hand, the family and the school have some important agreements. They both deal with immature minds, for whom certain kinds of motives are unsuitable. Neither can employ motives that are applicable only to grown men and women; they cannot appeal to consequences in the distant and unknown future. Children do not realize a remote effect, and they fail even to conceive many things that will one day have great power over their conduct. To talk to them about riches, honors, and a good conscience, is in vain. A half-holiday is more to them than the prospect of becoming the head of a business.

The position of immaturity is attended with another peculiarity, namely, that the reasons of a rule cannot always be made apparent. Sometimes they can, if not to the younger, at least to the older children. This is a highly-prized aid to obedience in every department of government.

There are many important points of agreement in the exercise of authority in every sphere—the family, the school, the relation of master and servant, ruler and subject, whether in the state at large or in any subordinate societies. For example:

1. Restraints should be as few as the situation admits of: the multiplication of grounds of offense is a great evil, and yet exceedingly natural.

2. Duties and offenses should be definitely expressed, so as to be clearly understood. This may not always be possible to the full extent, but should be always aimed at.

3. Offenses should be graduated according to their degree of heinousness. This too needs clearness of discrimination and definite language.

4. The application of punishment is regulated according to certain principles, first clearly pointed out by Bentham.

5. Voluntary dispositions are to be trusted as far as they can go.

6. By organization and arrangement the occasions of disorder are avoided. Quarrels are obviated by not permitting crowds, jostling, and collisions. Dishonesty is checked by want of opportunity; remissness, by the watchful eye and by definite tests of performance.

7. The awe and influence of authority are maintained by a certain formality and state. Forms and ritual are adapted to all the operations of law: persons in authority are clothed with dignity and inviolability. The greater the necessity of enforcing obedience, the more stern and imposing is the ritual of authority. The Romans, the greatest law-giving people, were the most stately in their official rites. A small portion of formality should accompany the slightest forms of authority.

8. It is understood that authority, with all its appurtenances, exists for the benefit of the governed, and not as a perquisite of the ruler.

9. The operation of mere vindictiveness should be curtailed to the uttermost.

10. So far as circumstances allow, every one in authority should assume a benign character, seeking the benefit of those under him, using instruction and moral suasion so as to stave off the necessity of force. The effect of this attitude is at its utmost when its limits are clearly discerned and never passed.

11. The reasons for repression and discipline should, as far as possible, be made intelligible to those concerned; and should be referable solely to the general good. This involves, as a part of national education, a knowledge of the structure of society, as being a regulated reciprocity among all its members, for the good of each and of all.

The points of comparison and contrast between the school and family have been noted. The more special distinction of the school, as compared with relations of authority in general, is resolvable into its main object—instruction, for which the condition that needs to be imposed is attention and application of mind, with a view to permanent intellectual and other impressions. To evoke, charm, cajole, compel this attitude, is the first aim in all teaching. The hostile influences to be overcome are such as physical inability and exhaustion, irksomeness in the work, diversions and distractions from other tastes, with the natural rebelliousness of human beings under authority.

The arts of proceeding are not the same for a single pupil, and for a class. For the single pupil, individuality may be studied and appealed to; for the class, individualities are not considered. The element of number is an essential feature; carrying with it both obstructions and aids, and demanding a very special manipulation.

It is in dealing with numbers that the teacher stands distinguished

from the parent, and allied to the wider authorities of the state ; exercising larger control, encountering greater risks, and requiring a more steady hand. With an individual pupil, we need only such motives as are personal to himself; with numbers, we are under the harsh necessity of punishing for example.

Good physical surroundings are known to be half the battle. A spacious and airy building ; room for the classes to come together and depart without confusion or collision—these are prime facilities and aids to discipline. Next is organization, or method and orderly arrangement in all the movements ; whereby each pupil is always found in the proper place, and the entire mass comprehended under the master's glance. To this follow the due alternation and remission of work, avoiding fatigue and maintaining the spirits and the energies while the teaching lasts.

After the externals and arrangements come the methods and arts of teaching, considered as imparting lucidity to the explanations, and easing the necessary intellectual labor of comprehension. If to this prime quality can be added extraneous interest or charm, so much the better ; but not to be at the expense of clearness, the first condition of getting through the subject.

The personality of the teacher may be in favor of his influence : a likeable exterior, a winning voice and manner, a friendly expression, when relaxing the sternness of authority. This is the side of allurement or attraction ; the other side is the stately, imposing, and dignified bearing, by which the master can impersonate authority and be a standing memento to the evil-disposed of the flock. It is seldom given to one man or woman to display both attitudes in their highest force ; but wherever, and to whatever extent, they can be assumed, they constitute a barrier to disaffection and remissness.

Any prominent displays of swagger and self-conceit operate against the teacher's influence, and incite efforts to take him down. It is possible to temper authority with an unassuming demeanor.

Much, of course, depends upon *tact :* meaning by that a lively and wakeful sense of everything that is going on. Disorder is the sure sequel of the teacher's failure in sight or in hearing ; but, even with the senses good, there may be absent the watchful employment of them. This is itself a natural incapacity for the work of teaching ; just as an orator is sure to fail if he is slow to discern the signs of the effect that he produces on his audience. A teacher must not merely be sensitive to incipient and marked disorder ; he must read the result of his teaching in the pupils' eyes.

That quietness of manner that comes not of feebleness, but of restraint and collectedness, passing easily into energy when required, is a valuable adjunct to discipline. To be fussy and flurried is to infect the class with the same qualities ; unfavorable alike to repression and to learning.

Any mistake, miscarriage, or false step, on the part of a teacher, is for the moment fatal to his ascendency. Such things will happen and they render undue assumption all the more perilous.

The stress of the teacher's difficulty lies in the heavings of a mass or multitude. The working of human beings collectively is wholly distinct from their individual action; a new set of forces and influences are generated. One man against a multitude is always in the post of danger. As units in a mass, every individual displays entirely new characters. The anti-social or malevolent passion—the delight in gaining a triumph—which is suppressed in the individual as against a more powerful individual, is reignited and inflamed in company with others. Whenever a simultaneous charge is possible, the authority of a single person is as naught in the balance.

It is often said that the teacher should get the collective opinion on his side—should, in short, create a good class-opinion. It is easier to deserve success in this than to command it. The fear is that, till the end of time, the sympathy of numbers will continue to manifest itself against authority in the school. There will be occasions when the infection of the mass is a stronghold of order, as when the majority are bent on attending to the work, and are thwarted by a few disturbers of the peace; or when they have a general sympathy with their teacher, and merely indulge themselves in rare and exceptional outbursts. While a teacher's merits may gain for him this position of advantage, more or less, he is never above the risks of an outbreak, and must be ready for the final resort of repression by discipline or penalties. He may still work by soothing applications, gentle and kindly remonstrance; he may check the spread of disaffection by watchful tactics, and by showing that he has the ringleaders in his eye; but in the end he must punish.

It is this position of constant preparedness for disorder, sometimes in isolated individuals and sometimes in the mass, that demands an air and manner betokening authority, and carrying with it a certain *hauteur* and distance; the necessity for which is the stronger, as the warring elements are more rife.

The discipline of numbers is impeded by two sorts of pupils: those that have no natural liking for the subject, and those that are too far behind to understand the teaching. In a perfectly-arranged school both sorts would be excluded from a class.—*Author's advance-sheets.*

EXPERIMENTS IN SOUND.[1]

SOUND is the sensation peculiar to the ear. This sensation is caused by rapidly-succeeding to-and-fro motions of the air which touches the outside surface of the drum-skin of the ear. These to-and-fro motions may be given to the air by a distant body, like a string of a violin. The string moves to and fro, that is, it *vibrates.* These vibrations of the string act on the bridge of the violin, which rests on the belly or sounding-board of the instrument. The surface of the sounding-board is thus set trembling, and these tremors, or vibrations, spread through the air in all directions around the instrument, somewhat in the manner that water-waves spread around the place where a stone has been dropped into a quiet pond. These tremors of the air, however, are not sound, but the cause of sound. Sound, as we have said, is a *sensation;* but, as the cause of this sensation is always vibration, we call those vibrations which give this sensation *sonorous vibrations.* Thus, if we examine attentively the vibrating string of the violin, we shall see that it looks like a shadowy spindle, showing that the string swings quickly to and fro; but, on closing the ears, the sensation of sound disappears, and there remains to us only the sight of the quick to-and-fro motion which the moment before caused the sound.

Behind the drum-skin of the ear is a jointed chain of three little bones. The one, *H* of Fig. 4, attached to the drum-skin, is called the *hammer;* the next, *A*, is called the *anvil;* the third, *S*, has the exact form of a stirrup, and is called the *stirrup-bone.* This last bone of the chain is attached to an oval membrane, which is a little larger than the foot of the stirrup. This oval membrane closes a hole opening into the cavity forming the *inner ear;* a cavity tunneled out of the hardest bone of the head, and having a very complex form. The oval hole just spoken of opens into a globular portion of the cavity, known as the vestibule; and from this lead three semicircular canals, *SC*, and also a cavity, *C*, of such a marked resemblance to a snail's shell that it is called *cochlea*, the Latin word for that object. The cavity of the inner ear is filled with a liquid, in which spread out the delicate fibres of the auditory nerve.

Let us consider how this wonderful little instrument acts when sonorous vibrations reach it. Imagine the violin-string vibrating 500 times in one second. The sounding-board also makes 500 vibrations in a second. The air touching the violin is set trembling with 500 tremors a second, and these tremors speed with a velocity of 1,100 feet

[1] From "Sound: A Series of Simple, Entertaining, and Inexpensive Experiments in the Phenomena of Sound, for the Use of Students of Every Age." By Alfred Marshall Mayer, Professor of Physics in the Stevens Institute of Technology. "Experimental Science Series for Beginners, No. II." New York: D. Appleton & Co.

in a second in all directions through the surrounding air. They soon reach the drum-skin of the ear. The latter, being elastic, moves in and out with the air which touches it. Then this membrane, in its turn, pushes and pulls the little ear-bones 500 times in a second. The last bone, the little stirrup, finally receives the vibrations sent from the

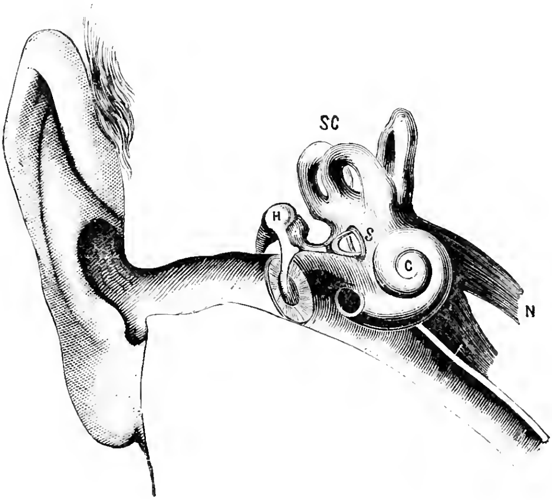


Fig. 4.

violin-string, and sends them into the fluid of the inner ear, where they shake the fibres of the auditory nerve 500 times in a second. These tremors of the nerve—how we know not—so affect the brain that we have the sensation which we call sound.

In Chapter V. it is shown that the mechanical actions, which finally result in giving us the sensation of sound, always have their origin in some vibrating body, and that this vibrating body may be either solid, liquid, or gaseous. The author, after showing that the vibrations of a solid (a tuning-fork) and of a liquid (water running through a toy flageolet) give origin to sound, presents to his readers—

An Experiment made with a Whistle and a Lamp-Chimney, showing that, as in Wind-Instruments, a Vibrating Column of Air may originate Sonorous Vibrations.—*Experiment 33.*—The chimneys of student-lamps have a fashion of breaking just at the thin, narrow part near the bottom. Such a broken chimney is very useful in our experiments. At *A*, in Fig. 25, is such a broken chimney, closed at the broken end with wax. A cork is fitted to the other end of the chimney, and has a hole bored through its centre. In this hole is inserted part of a common wooden whistle. At *B* is an exact representation of such a whistle, and the cross-line at *C* shows where it is to be cut in two. Only the upper part is used, and this is tightly fitted into the cork.

Inside the tube is a small quantity of very fine precipitated silica, probably the lightest powder known. Hold the tube in an horizontal position and blow the whistle. The silica-powder springs up into groups of thin vertical plates, separated by spots of powder at rest, as in the figure. This is a very beautiful and striking experiment.

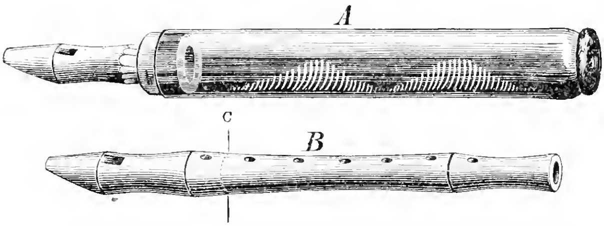


Fig. 25.

Experiment 33 a.—The following experiment shows that the sound is caused by the vibrations of the column of air in the tube and whistle, and not by the vibrations of these solid bodies. Grasp the tube and whistle tightly in the hands. These bodies are thus prevented from vibrating, yet the sound remains the same.

The breath driven through the mouth of the whistle strikes on the sharp edge of the opening at the side of the whistle, and sets up a flutter or vibration of air. The air within the glass tube now takes part in the vibrations, the light silica-powder vibrates with it, and makes the vibrations visible.

To exhibit this experiment before a number of people, lay the tube carefully on the water-lantern before the heliostat, and throw a projection of the tube and the powder on the screen. When the whistle is sounded, all in the room can see the fine powder leaping up in the tube into thin, upright plates.

From Chapter VI., which is on the transmission of sonorous vibrations through solids, liquids, and gases, we select—

Experiments showing that the Air is constantly vibrating while Sonorous Vibrations are passing through it.—We must now add to our apparatus an open metal A-pipe about seven and a half inches (nineteen centimetres) long, shown at *C* in Fig. 27. This pipe the organ-builder will accurately tune to your "A-philharmonic" fork.

Experiment 43.—Get a glass tumbler about two and a half inches in diameter and about three and a half inches deep, though any tumbler will do. Take a piece of window-glass about three inches square and place it over the tumbler. The glass must touch the edge of the mouth of the tumbler all around. Now slowly slide the glass so that the opening into the tumbler gets larger and larger, while the vibrating fork is held all the time over this opening, as shown at *A* in Fig. 27. Presently you will get an opening of a size that causes an intense sound,

much louder than any you have ever before heard from the fork alone. This is because the air in the tumbler is set in vibration, and adds the vibrations of its mass to those of the fork. That this is so you may prove for yourself by the following experiment:

Experiment 44.—Being careful not to move the glass plate from its present position (Experiment 43), stick it with wax to the tumbler. Pour a little silica into the tumbler, and then hold it horizontally, and vibrate the fork near its opening, observing attentively how the silica-powder is acted on by the inclosed vibrating air.

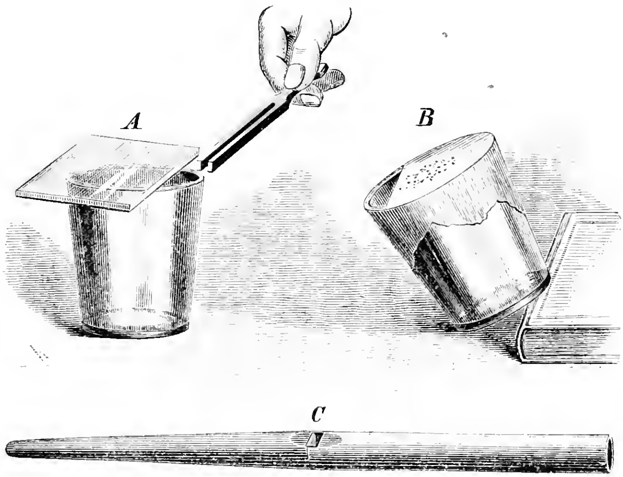


FIG. 27.

Experiment 45.—Take a piece of thin linen paper about four and a half inches square, and having wetted it paste it over the mouth of the tumbler. When the paper has dried it will be stretched tightly. Take a sharp penknife and carefully cut away the paper so as to make an opening as shown at *B* in Fig. 27. Make this opening small at first, and very gradually make it larger and larger. Hold the fork over the opening after each increase in its size, and you will soon discover the size of the opening which causes the air inclosed in the tumbler to vibrate with the fork, and thus greatly to strengthen its sound. You have now a mass of air in tune with the fork, and inclosed in a vessel which has one of its walls formed of a piece of elastic paper. With this instrument, which I have invented for you, you must make some charming experiments.

Experiment 46.—If the air in the tumbler vibrates to the A-fork, it will, of course, vibrate to the A-pipe, which gives the same note as the fork. Scatter some sand on the paper, and then sound the A-pipe a foot or two from it. The sand dances vigorously about, and ends by arranging itself in a nodal line parallel to the edges of the paper, in

the form of a U with its two horns united by a straight line. The vibrations of the pipe can only reach the tumbler by going through the air, and, as the sand vibrates when the tumbler is placed in any position about the pipe, it follows that the air all around the pipe vibrates while the pipe is sounding.

Experiment 47.—Sprinkle a small quantity of sand on the paper, and then, placing a thin book under the tumbler, so incline it that the sand just does *not* run down the paper, as shown in *B*, Fig. 27. Now go to the farthest end of the room and blow the pipe in gentle toots, each about one second long. At each toot, your friend, standing near the tumbler, will see the sand make a short march down the paper; and soon by a series of marches it makes its way to the edge of the paper and falls into the tumbler. I have, in a large room, gone to the distance of sixty feet (18.28 metres), and the experiment worked as I have just described it.

Experiment 48.—Again arrange the experiment as in Experiment 47, and standing three or four feet from the tumbler try how feeble a sound will vibrate the paper. If every part of the experiment is in good adjustment, you will find that the feeblest toot you can make will set the sand marching. To keep it at rest you must keep silent.

Experiment 49.—To show these experiments on a greatly magnified scale, place the tumbler in front of the heliostat (*see* "Light," page 79) so that the sun's rays just graze along the inclined surface of the paper. Cut off a piece of a match one-eighth of an inch long, and split this little bit into four parts. Place one of these on the inclined paper. Of course, the image of the tumbler is inverted, so the bit of wood appears to adhere to the lower side of the paper. If a little paper mouse cut out of smooth paper is used in place of the bit of wood, it is really amusing to see the mouse make a start at every toot of the pipe.

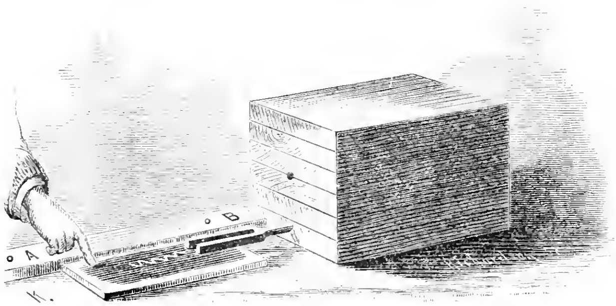


FIG. 21.

We make a long selection from Chapter VIII., which treats of the "Interferences of Sonorous Vibrations, and of the Beats of Sound," in order to set forth the manner in which the author has knit together his simple experiments.

Experiment 60.—Cut out two small triangles of copper-foil or tinsel, of the same size, and with wax fasten one on the end of each of the prongs of a tuning-fork. Put the fork in the wooden block, and set up the guide (as in experiment, Fig. 21). Prepare a strip of smoked glass, and then make the fork vibrate and slide the glass under it, and get two traces, one from each prong.

Holding the glass up to the light, you will see the double trace, as shown in Fig. 37. You observe that the wavy lines move apart, and

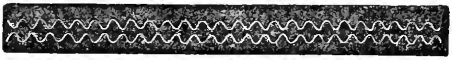


Fig 37.

then draw together. This shows us that the two prongs, in vibrating, do not move in the same direction at the same time, but always in opposite directions. They swing toward each other, then away from each other.

Experiment 61.—What is the effect of this movement of the prongs of the fork on the air? A simple experiment will answer this question.

Place three lighted candles on the table at *A*, *B*, and *C* (Fig. 38). Hold the hands upright, with the space between the palms opposite *A*, while the backs of the hands face the candles *B* and *C*. Now move the hands near each other, then separate them, and make these motions steadily and not too quickly. You thus repeat the motions of the prongs of the fork. While vibrating the hands, observe attentively

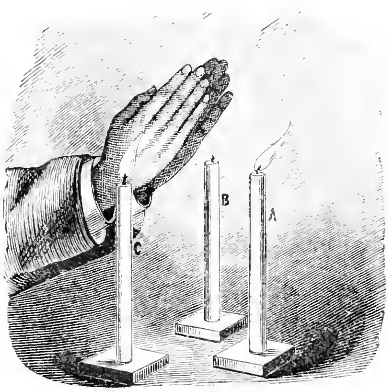


Fig. 38.

the flames of the candles. When the hands are coming nearer each other, the air is forced out from between them, and a puff of air is driven against the flame *A*, as is shown by its bending away from the hands. But, during the above movement, the backs of the hands have drawn the flames toward them, as shown in Fig. 38. When the hands are separating, the air rushes in between them, and the flame *A* is drawn toward the hands by this motion of the air, while at the same time the flames at *B* and *C* are driven away from the backs of the hands. From this experiment it is seen that the space between the prongs and the faces of the prongs of a fork are, at the same instant, always acting oppositely on the air.

This will be made clearer by the study of the diagram, Fig. 39.

This figure supposes the student looking down on the tops of the prongs of the fork. Imagine the prongs swinging away from each

other in their vibration. Then the action of the faces *c* and *c* on the air is to condense it, and this condensation tends to spread all around the fork. But, by the same movement, the space *r r* between the prongs is enlarged, and hence a rarefaction is made there. This rarefaction also spreads all around the fork. But, as the condensations produced at *c* and *c* and the rarefactions at *r* and *r* spread with the

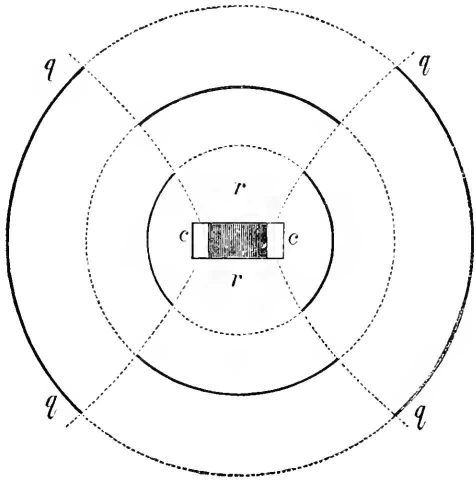


FIG. 39.

same velocity, it follows that they must meet along the dotted lines *q*, *q*, *q*, *q*, drawn from the edges of the fork outward. The full $\frac{1}{4}$-circle lines around the fork in Fig. 39 represent the middle of the condensed shells of air, while the broken $\frac{1}{4}$-circle lines stand for the middle of the rarefied shells of air.

Now what must happen along these dotted lines, or, rather, surfaces? Evidently there is a struggle here between the condensations and the rarefactions. The former tend to make the molecules of air go nearer together, the latter try to separate them; but, as these actions are equal, and as the air is pulled in opposite directions at the same time, it remains at rest—does not vibrate. Therefore, along the surfaces *q*, *q*, *q*, *q*, there is silence. When the prongs vibrate toward each other they make the reverse actions on the air; that is, rarefactions are now sent out from *c* and *c*, while condensations are sent from *r* and *r*, but the same effect of silence along *q*, *q*, *q*, *q*, is produced.

Experiment 62.—That this is so, is readily proved by the following simple experiment: Vibrate the fork and hold it upright near the ear. Now slowly turn it round. During one revolution of the fork on its foot, you will perceive that the sound goes through four changes. Four times it was loud, and four times it was almost if not quite gone. Twirl the fork before the ear of a companion: he will tell you when it

makes the loudest sound, and when it becomes silent. You will find that when it is loudest the faces c, c of the prongs, or the spaces r, r between them, are facing his ear; and when he tells you that there is silence you will find that the edges of the fork, that is, the planes q, q, q, q, are toward his ear.

Our space will only permit one more selection, and this we take from Chapter XVII., "On the Analysis and Synthesis of Sounds," in order specially to show how Prof. Mayer has placed within the reach of all teachers and students an instrument giving some of the most charming experiments in acoustics. The whole apparatus, if made at home, need not cost over seventy-five cents.

Experiments by which Compound Sounds are analyzed by viewing in a Rotating Mirror the Vibrations of König's Manometric Flames.—Take a piece of pine board, A, Fig. 51, 1 inch (25

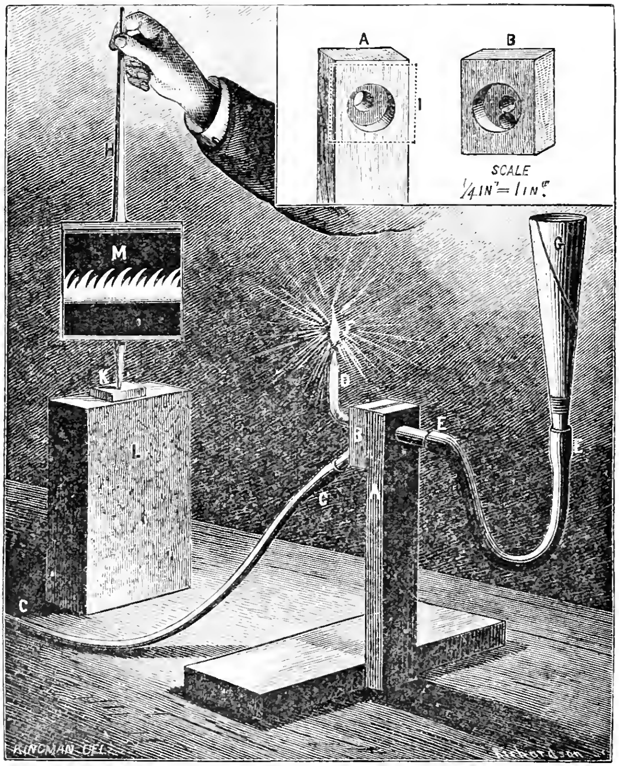


Fig. 51.

millimetres) thick, $1\frac{1}{2}$ inch (38 millimetres) wide, and 9 inches (22.8 centimetres) long. One inch from its top bore with an inch centre-bit a shallow hole $\frac{1}{8}$ inch deep. Bore a like shallow hole in the block B, which is $\frac{3}{4}$ inch thick, $1\frac{1}{2}$ inch wide, and 2 inches (51 millimetres) long.

Place a $\frac{1}{2}$-inch centre-bit in the centre of the shallow hole in *A* and bore with it a hole through the wood. Into this fit a glass or metal tube, as shown at *E*. Bore a $\frac{3}{16}$-inch (5 millimetres) hole obliquely into the shallow hole in *B*, and into this fit the glass tube *C*. Then bore another $\frac{3}{16}$-inch hole directly into the shallow hole in *B*. Put a glass tube in a gas or spirit flame and heat it red-hot at a place about two inches from its end. Then draw the tube out at this place into a narrow neck. Make a cut with the edge of a file across this narrow neck, and the tube will readily snap asunder at this mark. Then heat a place on the tube in a flame, and here bend it into a right angle, as shown at *D*, Fig. 51. Now fit this tube into the hole just made, as shown at *D*. These tubes may be firmly and tightly fitted by wrapping their ends with paper coated with glue before they are forced into their holes.

Get a small piece of the thinnest sheet rubber you can find, or a piece of thin linen paper, and, having rubbed glue on the board *A* around the shallow hole, stretch the thin rubber, or paper, over this hole and glue it there. Then rub glue on the block *B*, and place the shallow hole in this block directly over the shallow hole in *A*, and fasten *B* to *A* by wrapping twine around these blocks. Thus you will have made a little box divided into two compartments by a partition of thin rubber. Fasten the rod *A* to the side of a small board, so that it may stand upright.

Attach a piece of large-sized rubber tube to the glass tube *E*, and into the other end of the tube stick a cone, made by rolling up a piece of cardboard so as to form a cone eight inches long and with a mouth two inches (51 millimetres) in diameter.

Now get a piece of wood one foot long, four inches wide, and a quarter of an inch thick. Out of this cut the square, with the two rods projecting from it, as shown at *M*. The lower of these rods is short, the one above the square is long. Cut the end of the shorter rod to a blunt point, and with this point make a very shallow pit in the piece of flat wood *K* for the rod and square to twirl in. Glue the piece of wood *K* on the end of a brick, *L*. Get two pieces of thin silvered glass, each four inches square, and, placing one on each side of the square *M*, fasten them there by winding twine around the top and bottom borders of the mirrors.

Experiment 112.—Through a rubber tube lead gas to *C*. It will go into the left-hand partition of the box and will come out at *F*, where you will light it. Now place the mirror-rod in the shallow pit in *K*, and hold the mirror upright, so that you may see the flame *F* reflected from its centre.

Hold the rod upright and twirl it slowly between the thumb and forefinger, which should point downward and not horizontally, as shown in the figure. The flame appears in the mirror drawn out into a band of light with a smooth top-border. While twirling the mirror put the

cone to your mouth and sing into it. The sonorous vibrations enter the side *A* of the box, and, striking on the thin rubber, force this in and out. When it goes in, a puff of gas is driven out of the other partition, *B*, of the box, and the flame *F* jumps up. When the sheet of rubber vibrates outward, it sucks the gas into the box *B*, and the flame *F* jumps down. Therefore, on singing into tne funnel, you will see in the mirror the smooth top-border of the luminous band broken up into little tongues or teeth of flame, each tooth standing for one vibration of the voice on the rubber partition.

Place a lamp-chimney around the flame, should the wind from the twirling mirror agitate it, and be careful not to have the flame too high.

Experiment 113.—Another way of showing the vibrations of the flame is to burn the jet of gas at the end of a glass tube stuck into the end of a rubber tube attached to *F*. Now sling the tube round in a vertical circle, and you have an unbroken luminous ring; but as soon as you sing into the cone this ring breaks up into a circle of beads of light, or sometimes changes into a wreath of beautiful little luminous flowers, like forget-me-nots. To make this experiment, you will be obliged to have a tube with a larger opening than that at *F*.

This instrument will afford you many an hour of instruction and amusement. We have only space to show you a few experiments. Others will suggest themselves whenever you use it.

Experiment 114.—Sing into the funnel the sound of *oo* as in pool. After a few trials you will get a pure simple sound, and the flame will appear as in Fig. 52. Some voices get this figure more readily by singing E.

Experiment 115.—Twirling the mirror with the same velocity, gradually lower the pitch of the *oo* sound till your voice falls to its lower octave, when the flame will appear as in Fig. 53, with half the number of teeth in Fig. 52, because the lower octave of a sound is given by half the number of vibrations.

Experiment 116.—Sing the vowel-sound *o* on the note and you will

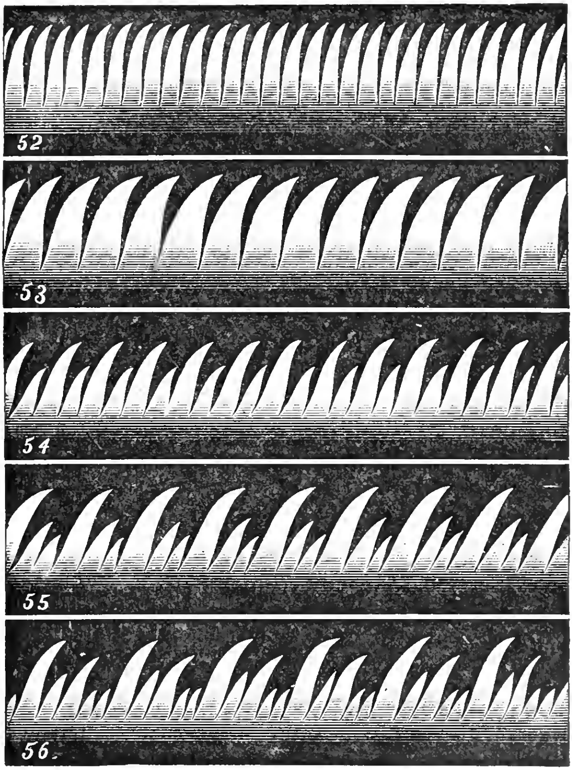
see Fig. 54 in the mirror. This evidently is not the figure that would have been made by a *simple* vibration. It shows that this *o* sound is compound, and formed of two simple sounds, one the octave of the other. The larger teeth are made by every alternate vibration of the higher simple sound acting with a vibration of the lower, and thus making the flame jump higher by their combined action on the membrane.

Experiment 117.—Fig. 55 appears on the mirror when we sing the English vowel *a* on the note f.

Experiment 118.—Fig. 56 appears on the mirror when we sing the English vowel *a* on the note c.

Examine attentively Fig. 55. This shows that the English vowel *a*

sung on f is made up of two combined simple vibrations. One of these alone would make the long tongues of flame, but with this simple vibration exists another of three times its frequency; that is, the vibration of greater frequency is the third harmonic of the slower. As the slower vibration, making the long tongues of flame, is f, the higher



Figs. 52, 53, 54, 55, 56.

must be c'' of the second octave above f. Each third vibration of this higher harmonic coincides with each vibration of f; hence each third tongue of flame is higher than the others.

Experiment 119.—In like manner the student must analyze Fig. 56 into its simple sonorous elements. Then he should, with the vibrating flame, examine the peculiarities of the various voices of his friends, and make neat and accurate drawings of the flames corresponding to them, so that he may analyze them at his leisure.

Experiment 120.—Blow your toy trumpet into the paper cone gently, and then strongly, and observe that the sound given by the trumpet is a complex one. Try if you cannot get a flame somewhat like that the trumpet gives by singing *ah*, through your nose, into the cone.

The student will soon find that different persons, in singing the same note, as nearly alike as they can, will produce flames of very different forms. This is because the voices differ in the number and relative intensities of the simple sounds which form them.

THE RADIOMETER.

By J. W. PHELPS.

SOME twenty-five years ago, when Foucault's ingenious experiment for proving the earth's motion on its axis was in vogue, the idea occurred to us that that fact might be proved in another way. Foucault's method, it will be remembered, consisted in the vibration of the pendulum in a fixed direction, the earth's motion being disclosed by the angular deviation of a given chalked line from that direction. In the pursuit of our own method we conceived the idea—which, though a very simple one, was not more simple than some others have been of experimentalists, both before and after the fact—that, if a small needle, say of dry wood, could be suspended from its middle by a torsionless thread, and be excluded from the air, it would retain any fixed direction, while a parallel line under it would change from that direction in proportion as the horizon turned from west to east. In order to carry out this idea we suspended a wooden needle by a thread of spider's web from the underside of the cork stopper of a large glass jar, and for additional security against possible currents of air placed the whole inside of a large chest.

On going to this chest to ascertain the result of our experiment, which we happened to do by night, and had to take a light with us, we were surprised to see, the moment we raised the lid, the needle begin to move! Our first thought was that we had made a great discovery: that light was a material substance, and that enough of that substance could emanate from one small candle to move a needle when freely suspended, in an horizontal position! The weight of light, of course, we knew must be infinitely small, if it had any weight at all; but then, by multiplying what little weight it might have by its known amazing great velocity, we did not know but that the motion which we witnessed might be produced in the way supposed. A little examination, however, into the matter, soon convinced us that our first impressions were erroneous.

We preserved the glass jar with the needle suspended in it for many months; and the most astonishing thing about it to us was that, however much the needle turned, though at times it would spin round with great and long-continued velocity, the thread of spider's web never

twisted nor broke. At one period it was placed on the mantelpiece, over an open fireplace, and whenever a puff of wind came down the chimney, driving the heat of the fire up toward it, the needle would then spin with amazing rapidity, reminding us of the whirlwinds that spin up from heated plains of sand or dust. Our visitors were astonished to see that needle whirling there, without any visible cause, and with no apparent attachment, for the thread by which it was suspended was so slight as almost to escape observation.

The application of the hand to the side of the jar would always cause the needle to move from a state of rest. It was very interesting to watch its motion at night, whenever the light of a candle entered the jar. It furnished a beautiful illustration of the effect which is produced upon the still night-air of summer when penetrated by the first rays of the rising sun. We may conceive that the whole atmosphere at that moment responds with infinite currents, breezes, and motions, awakened into new life from a night's rest by the heat of the sun's rays. Of course, light, as a substance, has nothing to do with the motion. It results entirely from the expansion of the air by the force of heat. Our needle moved on the same principle precisely—and on no other—that the windmill moves in a current of air.

If the glass jar were to be exhausted of its air, and the needle were then to move when struck by a beam of light, the motion might be supposed entirely due to that light; but it may well be doubted whether it is possible to produce a vacuum so perfect that it would be entirely void of gaseous substance of some kind. The planetary and starry spaces themselves are probably not entirely free from matter that would respond to the action of heat, if indeed such matter is not necessary for the transmission of light and heat. An infinitesimal portion of air, or even of vapor of mercury, spread through a large jar or receiver, would doubtless obey the same law of expansion under heat that is observed by the atmosphere in its densest conditions, and, when set in motion, would prove sufficient to move a freely-suspended needle.

As our instrument, devised for proving the rotation of the earth, did not prove that fact, but showed something else, so the radiometer, which was supposed to prove the material character of light, did not prove that fact, yet it may serve to show something else. But we do not perceive why it should be called a radiometer, any more than the windmill should be called by that name.

PLANTS AND THE PEOPLING OF AMERICA.[1]

By OTTO KUNTZE.

I HAVE spent some years as a botanist in the tropics of both hemispheres, and in the mean time have studied pretty thoroughly the tropical domesticated plants. In America and in Asia the principal domesticated tropical plants are represented by the same species; for instance, *Manihot utilissima*, whose roots yield a fine flour, the tarro (*Colocasia esculenta*), the Spanish or red pepper (*Capsicum annuum*), which is in far more general use than the black pepper, and whose numerous domestic varieties justify the inference that it has been cultivated from a very early period. This inference is still more valid in the case of the banana (*Musa paradisiaca*), called also the pisang, from which *Musa sapientum* is not specifically distinguishable; its fruits, in the cultivated state, are always seedless, and the varieties of the plant far surpass in number those of our apples and pears. Other cultivated plants found in both hemispheres are the tobacco, maize, cocoanut—the American origin of none of which is at all proved; then there is the tomato (*Lycopersicum esculentum*), and the cultivated bamboo, in which among millions of specimens hardly one has flowers. Thus the bamboo is not propagated by means of seed any more than is the tarro, the banana, the sweet-potato, or paritium. Of fruit-trees common to the Old and New Worlds I would further name the guava (*Psidium guava*), the melon-tree (*Carica papaya*), and the mango-fruit (*Mangifera Indica*). Finally, I may name *Paritium tiliaceum*, a malvaceous plant hardly noticed by Europeans, but very highly prized by the natives of the tropics. This tree, cultivated everywhere in the East and West Indies, South America, and the Malay Archipelago, supplies to the natives all the cordage they require; but in those countries cordage is not kept in stock as among us. If a rope is needed, a branch is broken off and stripped of its bark; the latter is divided into strips, which are held between the toes and twisted by the hands. When a load is to be carried from one place to another the natives usually secure it with a fresh cord of this kind to both ends of a bamboo carrying-pole. In the cultivated state this malvaceous tree is nearly always sterile, while the paritium-trees, which grow wild in the lagoons of the coast of Farther India, always bear seeds. This rope-tree appears to have existed in America before Columbus's time, for it was at an early period imported thence into the Canaries. What we may only accept as probable concerning this plant we know with certainty concerning the cultivated banana or plantain, which is also seedless. It was generally cultivated in America prior to 1492. Now in what way was this plant, which cannot stand a voyage through the temperate zone, carried to America, to the New World,

[1] Translated from the German by Dr. H. Hartogh Heys van Zouteneer.

where it certainly does not grow in the wild state? It must be remembered that the plantain is a tree-like herbaceous plant possessing no easily transportable bulbs like the potato or the dahlia, nor propagable by cuttings like the willow or the poplar. It has only a perennial root which, once planted, needs hardly any care, and yet produces the most abundant crop of any known tropical plant. On the average, a plantain annually bears nearly twenty kilogrammes, and sometimes a hundredweight, of most nutritious fruit, which at the same time possesses a delicious flavor. The stem then dies and the root gives out new shoots. No doubt the American race, closely allied as it is with the Mongolian, carried with it, when it migrated to America, the plantain as a cultivated plant from Asia where it grew wild. The plantain cannot have come from Africa or from Polynesia, where *musa* is also indigenous, for in that case African or Polynesian characters would exist in the aboriginal population of America. Some writers have supposed that this seedless, herbaceous, cultivated plant must have been introduced into America by shipwrecked seamen, because it can exist only in a tropical climate and in living specimens. But in our geological epoch a party of Mongolians shipwrecked in their primitive craft could never have reached the shores of America alive[1] at any point in the tropical zone, for they would be unprovided with sufficient food, and because the tropical distance between Asia and America is enormous, nearly thrice or four times as great as between Europe and America. Then, seamen are not wont to take living specimens of the plantain on their voyages; and, even if they did, these plants would be consumed as food in case of shipwreck.

Even if we suppose the plants to have escaped this fate, they would surely perish for want of fresh water. An hypothesis which rests on four improbabilities is worth nothing, and we might wager one against thousands of millions that no importation of the plantain into America has ever happened in that wise. The only hypothesis which remains is, that the importation took place while the polar regions enjoyed a tropical climate, and that the plantain was brought by the immigrating Asiatics by way of Kamtchatka and Alaska. This is the more probable, because many other tropical cultivated plants are in like manner propagated, not by seeds, but by "eyes," etc. Now, a cultivated plant which does not possess seeds must have been under culture for a very long period—we have not in Europe a single exclusively seedless, berry-bearing, cultivated plant—and hence it is perhaps fair to infer that these plants were cultivated as early as the beginning of the middle of the diluvial period. Moreover, the hypothesis of an immigration

[1] The Chinese and Japanese are acquainted with the plantain, and possess large ships in which pretty long voyages may be made. In the summer the plantain might live in the temperate zone. It can hardly be doubted that long before Columbus's time the junks of those peoples may have been wrecked on the Pacific coast of America. This seems an objection to the author's views.—TRANSLATOR.

of the Indians *via* a still tropical Northern Asia and North America is confirmed by their going naked. Had they passed through a climate like that of the Kamtchatka of to-day, they must have worn clothing; and a people that once has acquired that habit never abandons it afterward. Further, it must be observed that the American Indians generally are bad seamen, attempting only coastwise voyages; and this fact also renders the supposition of an oceanic immigration improbable. Whether man was the earliest cultivator of plants is doubtful, for we know of one or two species of ants which also regularly cultivate certain plants. We have, therefore, no reason to doubt that the very early ancestors of the Indians, however barbarous they may have been, cultivated a plant the culture of which is very easy and whose produce is most abundant, for it yields, as Humboldt has shown, on the same area, twenty-five times as large a crop and twenty-five times as much food-value as wheat.

I will consider the only two objections that have hitherto been brought against my hypothesis:

1. The importation of this plant by seamen who would have reached the American coast in their frail canoes, being favored by ocean-currents, is not possible, because within the tropics there is but one ocean-current from Asia toward America, namely, the equatorial current; but now this current, strictly speaking, does not touch Asia at all, but has its beginning at a point eastward of the Philippines and the Moluccas. If we make the very bold supposition—for a waste of water 80° wide, or twelve hundred geographical miles, has to be crossed, or two thousand geographical miles from the Moluccas—that such immigration is possible, then Polynesian and not Mongolian races would inhabit America, which is contrary to the facts of the case. 2. Or, supposing an immigration along a line near to the equator, we must presuppose a regular intercourse in prehistoric times between Southern China or Farther India and Central America, so that the later immigrants might make preparation for carrying out with them on a long sea-voyage living plants, as the banana, paritium, bamboo, etc.: for this supposition there is no ground whatever. Besides, many traditions current among various American tribes point to an immigration from the north, while the equatorial current only touches America at Panama.

I have still to meet another objection, namely, that the banana, when man began to cultivate it, must have had seeds (though this is so no longer), and that the seeds only were brought to America at an early period. This is inadmissible, because in that case the plantain must often have reverted to the wild state, like all other seed-bearing tropical fruits. But the plantain does not grow wild, though in tropical America it finds the same conditions of vegetation as in its native country, and hence thrives there. The wild plantain in India has small stony seeds, and is distributed widely by monkeys, bats, and insects,

which like the fruit but cannot destroy the seeds. In Asia wild, seed-bearing plantains are usually found growing in groups. In America, which has a much greater area of wilderness, the plantain must have spread far and wide, seeing that it has persisted in the wild state in the far more densely-inhabited East Indies. Therefore, it appears that in America the plantain has always been a seedless, cultivated plant, which can only have been introduced from Asia in preglacial times, through northern zones, for in that way alone was the immigration at all possible.—*Ausland.*

THE PLACE OF ENGLISH IN THE HIGHER EDUCATION.[1]

By A. B. STARK, LL. D.,

PRESIDENT OF THE LOGAN FEMALE COLLEGE.

I SHALL begin with an unequivocal statement of my position: the study of the English language and literature should occupy the central place—the place of honor—in every scheme of higher education for English-speaking men and women. This primacy I claim for two principal reasons: first, the knowledge obtained from this study is of most worth in the practical affairs of real life; second, the right study of English may be made the instrument of the highest culture of the mind.

All educators, I believe, are agreed that a thorough knowledge of our mother-tongue is of supreme importance to every educated man or woman. The friends of classical studies urge, among their strongest arguments in favor of Latin and Greek, that through a careful study of these languages is the shortest and surest way to a thorough knowledge of English; while, on the other hand, the advocates of the new education magnify the importance of studying English. I think it unnecessary to dwell on this first proposition, and shall, therefore, pass at once to a consideration of the *educational* value of the study of English.

In my first advocacy of the importance of studying English—in a quarterly review article printed seventeen years ago—I concede "that the study of the vernacular is almost valueless as a means of education, or as an instrument of intellectual culture and discipline." I hope I am wiser to-day; I certainly hold a very different opinion. In that article I reviewed all the important books on the subject then published, and yet all those works, with the exception of Marsh's "Lectures" and Latham's "Handbook," have been forgotten. A course of real study

[1] A paper read before the National Educational Association, Louisville, Ky., August 15, 1877.

in English was then unknown. A young man, whose time had been mainly given to Latin and Greek, might be expected to err in estimating the value of an undeveloped study.

After many years of experience in teaching I have come to believe that one may be liberally educated without knowing even Shakespeare's "little Latin and less Greek." Let us see what is claimed for classical studies by their friends. Dr. Jacob, in a lecture before the London College of Preceptors, after saying—what is most true—that it is "of the greatest importance to accustom young boys or girls to exercise such mental powers as *attention*, *observation*, *exactness or clearness of apprehension*, *the comparison of contrasts and similarities*, *generalization from a number of particular instances*, *the facility in tracing order in the midst of variety*," tells us that Latin "affords *peculiar opportunities* for promoting the exercise of the very faculties which most need to be drawn out and trained in boys, if they are to have an education which deserves the name." I think it will puzzle Dr. Jacob, or any one else, to show wherein Latin affords *peculiar* opportunities for promoting this training. Indeed, an advocate of science-teaching may as well make a similar claim for the particular science which he recommends. Certainly the botanist may accept this language as a statement of his claim. These results can undoubtedly be deduced from the study of English, and, in fact, from almost any real study.

We must, therefore, seek a higher ground for justifying the giving of so much precious time to the study of Latin and Greek. Let us try the real object of learning a language, to use it as a tool for receiving and conveying thought. The utter uselessness of Latin and Greek for this practical purpose, to almost every one who studies them, puts them out of court at once. After all the years spent in the study of these languages, not one in a thousand of our college graduates even learns to *read* them, and I doubt if there are ten teachers of them in America who can *read* them. There are many who can *translate* a Latin or a Greek book with the aid of a dictionary; there are others who can translate without the help of a dictionary; but *translating* is not *reading*. *To read* a book in a foreign language, you must *think* in its language—you must catch the thought at a glance without the intervention of English words at all. Now, who is there before me who can *thus read* an unfamiliar passage in Latin or Greek? Although I have spent many of the best years of my life in studying these languages, I am free to say I cannot do it. I have never known a man who could do it. Hence we know no more about the thought, the life, the philosophy, the poetry of the Greeks and the Romans, than we could have learned far more readily from good translations—using the correct translations of others in place of our own imperfect work.

All this, I know, is unpardonable heresy. My sin is made worse by the fact that I have fallen from grace. I was trained up in the good orthodox creed that the study of Latin and Greek is the chief factor of

a *liberal* education—the central source of "sweetness and light." These gods of Greece and Rome, having played their part, still "lag superfluous on the stage," and we must push them from their places to make room for something better—for modern languages and physical sciences. It may be said there is room for all, but I doubt it. Many eminent teachers in America and in England, writing to me in regard to a prize-paper on "Hamlet," printed last year as a specimen of the work done by my pupils, use expressions of surprise and admiration that have astonished me, and confess that they are unable to do work so good on account of the over-crowded curriculums of their colleges and universities. From numerous statements of this kind, I infer that, although able and learned men are employed in the department of English in our leading institutions, the students do not have time for any real, earnest work at English. There is too much of something else. We must find this encumbering *something* and drive it out, to make room for English. I think I see it in the form of Latin and Greek, and abstract mathematics in some colleges. Like the men of Ephesus who shouted "Great is Diana of the Ephesians" all the louder because they no longer believed in her greatness, we sometimes cling the closer to our idols after we see their utter powerlessness. So I have done, and in the curriculum of Logan Female College I permitted Latin to hold the place of honor after I had lost faith in its right. Meanwhile I was giving the primacy to the study of English in the actual work of the college. A copy of the college register having fallen into the hands of Mr. A. J. Ellis, formerly President of the English Philological Association and author of "Early English Pronunciation," he wrote me a long private letter, in which he severely criticises my inconsistency, and presses me to an open avowal of my real faith. I can best fortify the position I have taken by quoting his words, as I find them in a lecture before the London College of Preceptors: "It is perfectly absurd to speak of the humanizing effect of Latin and Greek, the grand literatures which they contain, their poetry, their philosophy, their history, the enormous influence which they have had upon the literature, poetry, philosophy, the whole tone of thought prevalent among civilized nations—I say that it is perfectly absurd to advance all these arguments, when the only condition which could make them valid is wanting. That condition is, that those who acquire them should be able to use them; that is, should be able to take up a Latin or Greek book, and read as most of those who have learned French and German would be ashamed not to do with French and German books; should be able rapidly by the eye to drink in the sense without the laborious consultation of dictionaries, without having to consider their own language at all; should be able to think in the languages so far as to speak and write in them with tolerable facility, making the words and phrases immediate representatives of thought. Without such power, we have no notion of the meaning or literature of a language. The words are tasks to get up,

or symbols to decipher, not the utterances of genius. . . . There are certainly not five in a hundred of those who learn Latin in our schools who can read with ease an unconned piece of Latin, or write off-hand a Latin letter on a familiar subject. I need not say a word about Greek. With all such people, learning Latin has been an arrant failure. They have done worse than waste their time. They have learned to make marks, to take places, to receive prizes, for mere botch-work."

These are the words of a man who devoted sixteen years of his early life to the dead languages, with a slight mixture of abstract mathematics. He tells us that, when he left Cambridge at the age of twenty-four, he was totally ignorant of the things he most needed to know, while his knowledge of Latin and Greek was "very small, poor, and inaccurate."

My classical friends must not attempt to refute me by the fallacy of an epithet; that is, by calling me *illiberal, narrow-minded.* It is just possible that there is some illiberality on the other side; it may be that if they knew more English they would think less of Latin and Greek. It is not enough for them to enlarge upon the *educating* power of classical studies. I am willing to admit what they usually claim for their favorite studies in that direction, but at the same time I hold that the highest and best discipline of mind is derived from a scientific study of English, German, and French; while the knowledge acquired in the process of learning these modern languages is incalculably more valuable in the affairs of real life than the knowledge obtained by pursuing the fullest course in the classics. The friends of the old education must meet this position squarely. Fine phrases about liberal culture will no longer be accepted in place of facts. We, too, believe in liberal culture. But if a knowledge of the highest thought of the ancient world, as embodied in words by its foremost thinkers, tends to liberalize and broaden the mind of a student, it must be trebly effective in its liberalizing influences to bring the student's mind up to the level of the highest thought of our own age. *We* are the ancients—"the heirs of all the ages." Our young men know vastly more than the wisest in the old time knew. They will, therefore, get most profit in knowledge, and equal profit in discipline, from the study of modern languages. After learning these, if they have leisure and inclination, they will *amuse* themselves by learning Greek and Latin.

Latin and Greek, being almost valueless in the work of fitting one for the duties of modern life, and by no means indispensable in the work of mental development, are, therefore, relegated to the position of pleasant accomplishments, or that of professional helps for ministers, teachers, and specialists. The student who is rightly trained in the study of modern languages will in a very short time—one or two years—learn the grammatical forms and acquire facility in the translation of Greek and Latin. So far am I from accepting the once popular notion—still heard of in out-of-the-way corners of the country—that

English is best learned through the study of Latin, that I maintain the opposite view; namely, the true natural method is to pass from English, which is easy for us, to the study of Latin, which is difficult—to pass in true logical order from the known to the unknown. I apply this great principle in my method of teaching English, beginning with the simple modern forms that are known to the student, and working back gradually to older and more complex forms which, if presented at once to the student, would seem as uncouth as Greek or Choctaw.

I must now say a few words about the method of teaching English; for, if the study of English is to occupy the foremost place in our institutions of higher instruction, the method of teaching it becomes exceedingly important. I am disposed to think that the unfruitfulness so often seen in English teaching is the result of wrong methods. Most destructive of all good results is the theory of the grammar-mongers who, not recognizing the fact that the English language *is a language* with facts and idioms worthy of independent study, attempt to bring its facts into conformity with the rules of the Latin grammar. It would of course be just as wise to take English grammar as the basis of a Latin grammar. English is a Teutonic language, with its own independent grammar, and must be studied *as English* and not as a corrupt form of Latin. It has borrowed words, but not grammatical principles, from the Latin. Whatever is common to the two languages comes to each alike from their common mother, the Aryan *Ursprache.*

The two great instruments of study are history and comparison.

The historical method of study is the only road to a critical knowledge of our mother-tongue; but before we can employ this method intelligently, we must get a clear conception of the *continuity* of English. We must recognize the fact that in English literature there has been an unbroken succession of authors from Cædmon to Tennyson, a period of twelve hundred years. The language of King Alfred and the language of President Hayes are one and the same ENGLISH TONGUE. "In fact," says Mr. Skeat, "there is no difference between modern English and that oldest form of it to which the name of Anglo-Saxon has been given, except such as has been naturally and gradually brought about by the mere lapse of time (occasioning the loss of some words and some alteration in the form and meaning of others), and by the enlargement of the vocabulary from foreign sources. In a word, old English is the right key to the understanding of modern English, and those who will not use this key will never open the lock with all their fumbling"—with all their attempts to use the counterfeit Latin-grammar key. No critical student, following the historical method, can stop in the fourteenth century in his search for old English. He can find no resting-place—no distinct break in the continuity of the language. Between the writers of one period and those of the preceding generation, the differences are always slight, even in times of most rapid

change—differences wholly insufficient to mark the death of one language and the birth of another.

Old English is synthetic, with an elaborate system of inflections; modern English is analytic, and almost inflectionless. We must not fall into the error of supposing that this change has been brought about by the Norman Conquest. Other kindred dialects, as Danish and Low Dutch, have undergone similar changes without the influences of external causes. So our mother-tongue has developed itself into its present forms, not by chance or by the will of Norman masters, but according to fixed laws. In its wonderful growth, and in all its seemingly lawless transformations, it has followed necessary rules. In our teaching, we must leave the unfruitful field of guess-work, and investigate the manner in which the general laws of linguistic change and development are applicable to the growth of the English language. It is impossible to explain words and grammatical facts, or idioms, except by their history. We must first know their affiliations and the facts that have preceded them; just as in the sciences of observation, such as chemistry or natural history, we can give an account of a fact only by knowing what has preceded it. For instance, in order to explain the manner in which a tree is formed, it is not enough to study the tree as it stands before us in its full-leaved glory; it is necessary to construct a *history* of the tree by the aid of accurate observations of the different states and forms through which it has successively passed. We are able to understand clearly what *is* only through a knowledge of what *has been*. We can discover the causes of a phenomenon only by taking a comprehensive view of antecedent phenomena. Grammar, in its true method, is the botany of language.

Modern English without old English is a tree without roots—a lifeless trunk. The words that have been imported from Latin and other sources have been ingrafted upon the English stock, and draw their life-nourishment from roots that strike deep down into the death-kingdoms of the oldest Teutonic speech.

Theoretically, we begin with what is oldest and farthest from us, to explain all that follows in the course of time; but practically, in learning and in teaching, we begin with what is nearest and best known, and work back to what is less and less familiar.

As an illustration of what I mean by studying a fact historically, take the plural of the word *foot*. The boy or girl learns in the elementary school that the plural of *foot* is *feet*, and accepts it as an ultimate, inexplicable fact. But the man or woman in the college or university may ask why the plural is *feet* and not *foots*. I am afraid there are some very learned teachers of Latin and Greek who could not answer, except with a growl about the lawlessness of the English language. However, it *is* explicable. Going back twelve hundred years, we find our present form *fôt*, *fêt*. There seems to be an end of our search. But we can go farther; for, looking into the old Saxon,

the language as spoken by our forefathers in their old home on the Elbe before they settled in England, we find a plural in *i*, *fōti*. But it is a known law, holding good in all the Teutonic dialects, except the Gothic, that *a* or *o* is changed into *e* through the influence of *i* in the following syllable; hence *fōti* became *fēti*. After a time, this final *i*, the true sign of the plural, was dropped, and then the modified *e* was considered the sign of the plural. This *Umlaut* is itself an ultimate fact, like gravitation in physics, inexplicable in the present state of our knowledge.

Whatever help to a right understanding of the constructions and inflections of modern English may be obtained from comparing them with the forms and laws of the Latin language, it is clear that vastly greater help may be obtained from studying them in the light of their own history.

The second instrument of fruitful study is comparison. This opens a vast field for investigation; for we must compare our English tongue with all the cognate Aryan languages; but especially with German, Dutch, Danish, Icelandic, Gothic—all the Teutonic tongues, old and new—and with those languages with which it has come into contact during its long and wide-reaching history. English, the grandest language in the history of humanity, has the most extended affinities and historical connections.

As an example of an English form that can be explained only by comparison with a cognate dialect, take *ed*, the sign of the past tense. No clew to the origin of this termination can be found in the English of any period. Our knowledge of Latin and Greek is again useless. In this case the Gothic will help us to the true explanation; for it is simply a reduplicated perfect of the verb *do*, *did*. Hence the old English *lufode* is merely, I love *did*, that is, I *did* love.

Thus studying English in its historical development, and comparing it at every point with the languages with which it is connected by kinship or by contact, the student sees language in every form in which an Aryan tongue can appear, and may learn every important truth of linguistic science. Having learned English in this way and gotten a knowledge of French and German as collateral helps, the student will enjoy the best fruits of learning languages—a liberal culture, a critical knowledge of his mother-tongue, an intelligent insight into the laws of language, and a key to what is best, usefulest, and most inspiring in literature.

But, to learn the language in its living power, it is necessary to study it in its literature. The language is the body, the literature is its soul; they can be rightly understood only by studying them together. In a course of higher instruction in English, grammars, rhetorics, and histories of literature, are useful only for reference. It would be hard to invent a course of study more useless than that which fills the mind of the student with barren dates and facts in the

lives of our great writers, and with the opinions of other men about their works.

The student must go directly to the literature and *study* its master-pieces in their *original* forms, with the very spelling and punctuation of the authors. *Study* each work in the most thorough way: *study* every part, every sentence, every line, every word: *study* every allusion, every illustration, every figure: *study* every thought, every opinion, every argument: *study* every fact in the author's life, every fact in the history of his time, that will help in any way to an understanding and appreciation of the work. No book of extracts should be used. A work of genius must be studied as a whole. If you can give but a few days to a writer, study some *entire* short work in preference to using extracts from larger works. A student will get far more profit out of Milton's "Lycidas" studied in this way than from going through "Paradise Lost" in the ordinary way.

Take a play of Shakespeare—what an instrument for the highest culture! How rich the rewards of diligent labor in this mine! What more inspiring thing is possible for a human mind than to be brought so near to the foremost mind of all this world's history? I am not disposed to undervalue the grand literatures of Greece and Rome; they mark the highest tide of human thought in the old-world civilization; and yet, in their combined worth, they are outvalued by Shakespeare alone—without counting in the worth of Chaucer, Langland, Spenser, Bacon, Hooker, Milton, Pope, Wordsworth, Tennyson—may the roll stretch out "to the crack of doom!" How unwise in us, in our anxiety to teach our children the language of Plato and Cicero, to leave them in ignorance of the language of their own forefathers! I trust the time will speedily come when no man or woman, who is unable to read at sight a page of English of any age from Alfred to Victoria, will be considered *liberally* educated, whatever else he or she may know.

Certainly much has been done in the last ten years to encourage us. In the time of Richard II., in 1385, English was admitted into English schools as a teaching medium: the close of our century will witness its full admission into English and American schools as a teaching subject. The future historian will record the significant fact that in our age the boys and girls of England and America were for the first time instructed carefully in the great classics of their mother-tongue—that they knew Chaucer, and Shakespeare, and Bacon, as the boys and girls of Greece knew Homer, and Sophocles, and Plato.

Greek itself was admitted, as a subject of study, into the English universities in the sixteenth century, only after a long and fierce battle between the Greeks and the Trojans of that day. "There were many, then, who from various points of view echoed the sentiment expressed by the Duke of Norfolk in 1540. '*I never read the Scripture,*' said that adherent of the departing age, '*nor never will read it. It was*

merry in England before the new learning came up; yea, I would all things were as hath been in times past.' Who could laugh at these words of a strangely troubled spirit? Rather one might weep over them; there is a certain pathos in the helpless embarrassment and despair they reflect; but one can see they were not wise, provident words; one cannot regret that the 'new learning came up.' But not altogether unlike is the sentiment sometimes heard in these days of like unsettlement and transition."

The old Duke of Norfolk is the prototype of many living men; from an undefined dread of the New, they cling to the Old, in helpless, despairing bewilderment. As the world spins swiftly down the grooves of change, they become dizzy and sigh for rest. They smile at the narrow-mindedness of conservatives in other ages, but fail to see the same weakness in themselves.

"Surely the wise course now is," says Mr. Hales, "not to set our faces against the incoming studies, but to do our best to regulate and order their admission. Let us give these strangers a judicious welcome. Let us frankly and generously examine what recommendations they have to advance for themselves. Let us banish utterly and forever from our minds the notion of finality in education. Let us recognize that all our efforts are but tentative, and that we are yet an immeasurable distance, not only from absolute perfection, but from that degree of perfection which is attainable. May it not be, indeed, that we are at present in an extremely rudimentary stage of advancement in this momentous respect?—that the question of education is yet in its veriest infancy? Perhaps we are yet at the very foot of the mountain, and have not really commenced the ascent. Not odder, it may be, in our eyes is the educational system of the middle ages than our present system will be according to the decisions of posterity. These possibilities should surely make us, not reckless revolutionists, but thoughtful, considerate reformers. The changes that are now making will in their turn perhaps be modified or superseded. There is no such thing as an educational canon which closes and is complete."

Our King Arthur, the spirit of the age, commands us "to fling far into the middle mere" the brand Excalibur, the marvelously-wrought Greek tongue. Let us not, like the bold Sir Bedivere, clouded with our own conceits, betray our king; but, while remembering the wonders of the brand and admiring its haft twinkling

> ". . . . with diamond studs,
> Myriads of topaz-lights, and jacinth-work
> Of subtlest jewellery,"

> ". . . . strongly wheel and throw it."

> "'The old order changeth, yielding place to new,
> And God fulfils himself in many ways,
> Lest one good custom should corrupt the world.'"

The rising glories of the new era far outshine the splendors of the past.

> "Then from the dawn it seem'd there came, but faint
> As from beyond the limit of the world,
> Like the last echo born of a great cry,
> Sounds, as if some fair city were one voice
> Around a king returning from his wars.
> Thereat once more he moved about, and clomb
> E'en to the highest he could climb, and saw,
> Straining his eyes beneath an arch of hand,
> Or thought he saw, the speck that bare the king,
> Down that long water opening on the deep
> Somewhere far off, pass on and on, and go
> From less to less and vanish into light.
> And the new sun rose, bringing the new year."

THE ICE AGE.

By L. P. GRATACAP, Ph. B.

II.[1]

SOME months ago we described very rapidly the principal features of that widely-extended and enigmatical formation known as the Drift, and in conclusion indicated an intention to consider the views of geologists as to its cause, and in particular illustrate the paramount claims to our acceptance of the so-called Glacial Theory. In this paper those hypotheses are given, accompanied by a proof of the manifest power of existing ice-streams, thus offering the most striking argument for their colossal potency in times when their size and duration were factors in their influence, fully commensurate with the continental ravages we attribute to them.

A great variety of theories have been submitted to the world as possible explanations of the appearances we have reviewed, and, though we cannot occupy ourselves with their discussion, it may be interesting, from their singularity and number, to enumerate such as have arisen.

First is the theory of Deluc, who supposed the erratics to have been thrown upward in the air by the same force that elevated the mountains, and that in their promiscuous descent they rolled and tumbled everywhere.

Second in order is the hypothesis of De Buch and Escher, who imagined that an immense deluge swept the bowlders along its surging course, and landed these blocks upon the acclivities of mountains, through the stupendous impetus they had acquired in its midst.

[1] No. I. was published in The Popular Science Monthly for January, 1878.

Third is the presumption of many that they are the wreck of a mantle of rocks of similar kinds which once covered the surface, and by different agencies have been tossed into alignments, heaped into hills, or left undisturbed upon the mountains.

Fourth, Dolomieu supposed that the summits of the Alps, and those of the Jura Mountains, were formerly connected by a regular incline, down which the masses of rock rolled, so that bowlders from the Alps got perched upon the Jura, and that during subsequent convulsions the ground sunk and assumed its present form.

Fifth, Venturi suggested very early the aid of ice, as glaciers and floating ice, to explain their transportation.

Sixth, a view, received by several, regarded the Jura range to have been once a level plain at the feet of the Alps, and that, when it had become strewed with bowlders, torn by frost and torrents from the latter, it was elevated into a line of hills carrying up its old accumulations.

Seventh, M. de Buch, developing the first theory, thought that the erratics were a consequence of the elevation of the Alps posterior to the deposition of the Tertiary.

Eighth, the Noachian deluge was burdened with the responsibility of their dispersion.

Ninth, glacial action, as explained by Prof. Agassiz.

Tenth, ancient alluvial action, identical in nature with that known at present.

Eleventh, action, by its tractile strength, of the receding waters of the ocean, as mountain-chains were successively upheaved above its surface.

Twelfth, elevation of the arctic seas, which caused a flow of water from the polar regions, transporting ice loaded with rocks and gravel southward.

Thirteenth, icebergs.

Fourteenth, an explanation of the phenomena in the United States, viz., a drainage of a vast inland sea through the valleys of the St. Lawrence, Hudson, Susquehanna, Ohio, etc., accompanied or followed by a *débâcle* of ice and drift from the north.

Fifteenth, a change in the axis of rotation of the earth.

Sixteenth, collision with a comet, which extraordinary jolt loosened the rocks, and rattled them from the mountain-peaks to the adjacent plains.

Seventeenth, shrinkage of the earth, increased velocity of rotation, and consequent rush of arctic waters to the equator, carrying bowlders.

In the above enumeration some theories will be observed to have only a local application, and were originated at a time when the dispersion of bowlders was not known to have so universal a character. Of these seventeen hypotheses we believe it would be impossible to insist seriously upon more than two classes: those which attribute the phenomena to the action of water, and those which enlist the agency of

ice either as glaciers or icebergs, or both. A slight inquiry into the nature of aqueous erosion must instantly discredit those views which rely upon its efficacy, and relegate them with the rest to unqualified rejection.

Water, though supplied in torrents so tremendous as to transport the enormous bowlders which are now found scattered so far from their origin, would toss and tumble these masses over the subjacent rock, breaking, fracturing, and denting the latter, but never impressing it with deep, straight furrows for miles, or scoring it with delicate and reticulating striæ.

Again, the numerous pebbles and stones which are found upon and through the topmost soils, in gravel-beds and sand-heaps, would have been smoothly rounded like beach-worn agates, and not, as they really are, tattooed and etched with fine lines running the length of the stone. In the grooves of the rock, and in the fine lines of the pebbles, we have evidence of a body firmly held upon the engraved surface, and passed along with undeviating directness and irresistible power. Prof. Agassiz has traced these flutings upon the rocks of Maine for miles, up hill and down dale, across rivers disappearing upon one side, and reappearing upon the other; and it is beyond possibility to have a plunging torrent of water, charged with stones and rocks, pursue such continuous and definite traces over the hardest rock. More than that, the action of water has been recorded alongside of these very grooves, both in this country and the Alps, as if to invite attention to the opposite character of the two inscriptions. The original traces are firm, direct rulings, and the water-marks beneath them, as in rocky troughs, are waving lines and cracks of denudation following the relative softness of the rock.

Untenable as this theory is, after such considerations, it seems more inadequate when we remember that this element was to transport for leagues masses weighing hundreds and thousands of tons, and to raise them to almost inaccessible altitudes, to arrange them in long succession across intervening slopes. We find, on the contrary, that moderate-sized bowlders have sunk to the bottoms of streams, which have removed the soil and lighter material upon which they rested, allowing them, otherwise undisturbed, to sink almost vertically to their beds. Lastly, the high mounds and "horsebacks" associated with this era, composed of unassorted gravel, pebbles, bowlders, and clay, would have been arranged in superimposed layers. Their present composition is almost irrefragable evidence that water had no part in their construction.

On the other hand, the demonstration of the adequacy of the glacial theory to account for these phenomena is found only in a study of those glacial effects which are contemporaneous, or have been witnessed within the memory of man. By establishing an exact accordance between these latter, wherever examined, and the indications of erosion and transportation wide-spread over the continents, we prove the iden-

tity of both, and legitimately conclude that the agency in each case was the same.

And let us select the Alps, as the first field for our explorations, renowned for the phalanx of illustrious minds who have studied this subject there, and famous as embracing those districts where the presence of traveled blocks first aroused inquiry, and their significance gave birth to the theory we are testing.

. The Alps cover with their various arms, encircling ranges and subordinate elevations, all Switzerland ; her lakes are nestled within their valleys, her rivers spring from their frigid slopes, her cities rest upon the *débris* of their attrition, while the strange and romantic loveliness which surrounds their fields of ice cover it as with a garment of imperishable beauty. The Alps are the result of gigantic upheavals, probably conducted through ages, which succeeded each other throughout the Tertiary age, and were continental in their extent. The Pyrenees, the Julian Alps, the Balkans, the Apennines, and Corsica, were elevated in this series of vast perturbations, a long range of towering mountains whose influence upon physical and social development has been as marked as the revolution it signalized in the world's topography. Europe, which had worn the flora of America, then lost it, and the sassafras, liriodendron, maple, and magnolia, failing to survive the climatic changes which intervened, yielded before the gradual growth of distinctively European species.

The Alps, after passing up along the eastern boundary of Piedmont, irregularly in long, deep bends and winding arches, run east and west, gathering upon their flanks innumerable lesser ranges, and knots of mountains, or in places subdividing into new and splendid lines of peaks which, diverging to the north, afterward unite with the parent chain or melt into the plain of Germany, through successive steps. A great congeries of intermingling and twisting ranges communicates the original disturbance over Switzerland, and the radiate lines of agitation may be traced southward upon the plains of Piedmont, through the Apennines into Italy, and by the Illyrian Alps into Dalmatia. The Alps inclose valleys and plateaus ; their highest summits are scored by deep gulches which descend their sides ; and broad crevices, ravines, and passes, ramify along their slopes. Into these troughs, far above the snow-line, fed by confluent furrows, the snows of winter have collected, and heaped up layer upon layer accumulated to great depths. The water of the melted surface percolating through these subjacent films, an increasing pressure has solidified them to a semi-icy state. Slowly in these deep fields of snow, by pressure, by alternate thawing and melting, the molecular condition of the mass undergoes a change, and becomes compacted into crystalline ice. Before this change is consummated, the mass of snow, ice, and congealing water, is called the *névé*. Thus formed, there emerge from these upper reservoirs vast sheets of ice which pass down between cliffs and crags, winding over

rocky beds, and through the avenues of least resistance, sometimes fusing together into solid seas amid the mountains, elsewhere stealing in sinuous and gleaming currents to the plains beneath. These solid masses, fastened like inexorable wedges into the mountain-clefts, possess motion, moving like a river, faster at the top than at the bottom, in the centre than along the sides, and in curves fastest upon the long curve; they, like rivers, also perform the offices of transportation and erosion. Long lines of fragments, detached by frost or avalanche, cover their surfaces in medial and lateral moraines, whose collected masses are poured over the glacier's extremity, where in stream or river it ends its course. Immense heaps of *débris* thus indicate, at the mountain's foot, the accumulated waste of its substance through the years of the glacier's slow and perpetual advance, and also record, as they lie beyond the present wall of the glacier, the past periods of its greatest extension. They grind the beds they pass over, the walls of their stony vaults are polished and inscribed, and the bowlders brought in contact with their stupendous powers of attrition are rubbed into brilliant surfaces and scored with rigid lines. Thus advancing, crevassed, convulsed, and rent into gaping chasms, loaded with blocks of stone, the glaciers are grinding down the everlasting hills and lowering the proud summits of their birthplace to the plain. Imagine half a hemisphere covered by a universal glacier whose powers of abrasion and transportation are proportionately enlarged: will not the appearances we are attempting to explain be adequately accounted for by so tremendous an agent? Let us turn to contemporaneous glaciers of the Alps and elsewhere for an answer. In mentioning characteristic instances of glacial action the glaciers are referred to by name only, as our space does not permit their reference to appropriate groups. The Glacier des Bois, as it projects its frozen tongue like a crystal wedge within the valley of Chamouni, reveals the mass of *débris* it has dragged down with it from the sides of Mont Blanc, in a high and rocky moraine over whose eminence the glacier pours its broken and shattered columns. In 1820 this glacier reached its frigid finger among the cultivated fields of neighboring villages, and in its slow retreat left an enormous bowlder perched upon a slope, and tracts of fragments spread in stony desolation up to the doors of the threatened hamlets. The Glacier of Tacconay has similarly withdrawn to its recesses, but strewed along the path of its former progress groups of bowlders which reach beyond the Arne. The rocks about are polished and furrowed, hillocks have been moulded into *roches moutonnées*, and upon their summits huge blocks deposited.

Seven thousand feet above the sea, upon the Col de Bellevue, erratic blocks are found, where no tidal force could ever have brought them, and these mingle with the present moraine of the Glacier de Bionassay, so that, as Forbes remarks, "it is impossible to say where the erratic phenomenon ends and where the glacial phenomenon begins." The Glacier

de Miage, with its wild and ruffled surface breaking in cataracts of splendor down its steep defile, by its unceasing attrition upon the mountain-side, and its perpetual transport of bowlders, has piled up, far out in the valley it occupies, a long and high slope of gravel and rocks, whose impervious sides dammed up the *allée blanche* and formed Lac Combal. So immense became the accumulations of *débris* that they consolidated into an impregnable hill, around whose base the glacier poured its divided stream. The Glacier la Brenna in 1767 was much contracted, while in 1831 new accretions caused it to reach out and attack with such vigor a promontory in its path as to shatter it with fissures, and compel the removal of a chapel upon its crest. Upon this same glacier Principal Forbes has observed the very act of glaciation, its method and effects. One side of the ice was exposed and found by him thickly set with nodules, pieces of granite as large as cherries, and protuberances of stone, while beneath this armed surface lay the limestone, over which it had just passed, with its face finely lined and graven in the direction of the glacier's motion. This glacier, now shrunken from its former imposing magnitude, once erected below its present terminus moraines of enormous size, while in its retreat it paved the land, predestined to sterility, with thickly-scattered fragments. On the west bank of the Mer de Glace, two hundred and forty feet above the present level of the glacial *débris*, traveled rocks lie in morainic alignments, and the bed-rock is scratched and abraded, indicating an ancient margin of the glacier in days when its frigid tide was swollen by greater additions and more favorable climates.

The distinction between aqueous action upon the rocks and mechanical abrasion is easily understood, and their presence readily distinguished. Forbes observed a face of limestone marked with grooves many yards in length, and, nearly horizontal above them, he found the marks produced by flowing water charged with fragments. The latter were blunt, irregular, and blotchy, having no continuity, and strikingly contrasted with the straight rulings below them. Furthermore, the memorable flood of water which devastated the valley of Bagnes, a mass over five hundred million cubic feet in volume, which swept up bridges and houses, snapped trees asunder, and transplanted a colony of buildings, was yet unable with all its Titanic violence to move large bowlders which it encountered even through inconsiderable distances.

In our glance over the glacial fields of to-day, leaving the inferences from those facts mentioned to be drawn themselves, let us briefly inspect the frozen valleys and important ice-streams of Norway. The backbone of the Scandinavian peninsula lies in Norway, reaching from Drontheim to the North Cape in the long neck of the Kiölen Mountains. This chain attains in places an elevation of six thousand feet, and again stoops to less than two thousand, receding at times from the shore-line, and again pushing out upon the ocean, till, as in the Loffoden Islands, many of its conspicuous summits stand insulated among its billows.

North of latitude 68° north the range "scatters," and finally sinks into slight and timid heights or gradually disappears. South of Drontheim this central axis unfolds and deliquesces into a series of separate lines of elevation, forming the wide expansion of Southern Norway which, thickened and braced by ridges of crystalline rock, held back the force of the North Sea, and bore the searching pressure of the northern glacier, when in a single and enormous surface it invaded Europe. This southern extension of the Norwegian highlands has less height than the narrow fork which enters the north, and is really a succession of table-lands interrupted by occasional peaks, or narrow and precipitous valleys. These level floors, barren and monotonous, constitute over forty per cent. of the surface, reducing the available land for cultivation, roughly estimated, to less than eleven per cent. The coast of Norway along its entire extent is deeply penetrated by a complex system of *fiords*, long channels which wind in almost inextricable detail amid its highlands and at the base of its loftiest summits. Running for miles inland, and connected with the labyrinth of straits which fimbriate the shores and break the outlines with detached islands, these wonderful expanses expose the most bewitching and lovely scenery which Norway boasts. Glacier, snow-capped mountain, green fields verdant under cultivation, villages, and dizzy cliffs, are exquisitely blended into a diversified panorama of sublimity and beauty.

The glaciers of Norway are not so imposing, so numerous, or so accessible, as those of the Alps. The peaks are frequently too isolated and too steep, the valleys too shallow and too small, and the stretches of table-land too frequent, to permit the best exhibition of glacial forms; yet the accumulations of snow are very formidable. The snow-fields of Justedals Bracen, which feed several glaciers, the largest of which is only one-seventh the size of the Aletsch glacier in the Alps, stretch for fifty miles upon one range, and cover an area of four hundred square miles. Sognefield and Ymesfield form imperfect reservoirs of snow, and generate only inferior though numerous ice-streams, falling off their declivities through abrupt and narrow passes. The Fondalen Mountains and the Borgefield both release glacial currents, in some instances impinging their icy barriers upon the sea, but all subordinate in interest.

Sulitelma, the highest mountain within the arctic circle, occupies a conspicuous centre of glacial activity. It dominates over an extensive region of elevated and snowy ranges, and distributes its frigid emissions on either side to Lapland or to Norway. The peaks of the Lofoden Islands reach above the snow-line, but no adequate footing is afforded for the formation of glaciers, though the islands of Ringvadsö and Kraagen contain glaciers, which in the first instance have pushed their moraines to the water's edge. If we now examine the actual evidence of glacial action, we shall find it analogous to that we have witnessed in the Alps, except that it is perhaps less emphatic. The

slaty rock of Norway fails to retain the erosive markings of the ice-plough, and has lost frequently its graven surface through frost. Again, the more characteristic traces must be found upon the steep slopes and narrowed exits of the snow-fields, and these are not always readily approached.

Along Drontheim Fiord, and in many localities over the shore and bays, the *roches moutonnées* appear repeatedly, and at Sognefiord the hard conglomerate, rounded into these huge knobs, is graven with channels and grooves. At Moranger Fiord the impressions increase in distinctness as we approach the glacial ridges which overhang it. The Bandhuus Glacier at one time extended to the sea, and the mingled heap of rocks it pushed before it now lies, a crescent of desolation, in its old path. One hundred years ago, by local traditions, the Suphelle Glacier, among the Justedals glaciers, extended across the entire valley into which it now debouches, and a series of recent moraines indicates its retreat. About 3,600 feet in front of the Krondal and Nygaard glaciers, terminal moraines, unmistakably modern, are seen, while the evidence of their erosive action is found in the increasing definiteness of the rocky striations as we advance over the land last scored toward the glacier, this same track being sown with bowlders and pebbles, relics of their past ravages. Two hundred feet above the Nygaard, on the face of the cliff, we can read, as legibly as we do the record of the fallen tide, the annals of its past increase; and local tradition, stories of destruction, removal of villages and houses, corroborate this ocular examination. In short, in Norway, as in the Alps, the characteristics of glacial denudation, as seen in the forces now at work, appear to perpetuate the memory of agencies which, on a magnificent scale, operated upon continents.

Turning our eyes from the picturesque surprises of the Scandinavian cliffs and streams, let us fix them upon the multitudinous slopes and the confused outlines of the Himalaya Mountains, as they rise to the plains of Thibet, and read their lesson. Here we shall encounter the same arctic currents cleaving the fissures

"Of vales more wild and mountains more sublime."

Upon their surface we see the same long avenues of bowlders, fed in their tedious course from every faltering cliff or frost-riven peak, and their ancient channels indelibly indicated in the disordered *débris* of rocks and pebbles filched from quarries leagues away.

The Himalaya Mountains mark the northern frontier of India, and form the most important section of that long axis of elevation which reaches from the Bosporus to the Pacific, and separates, as a similar girdle does in Europe, the northern plains and table-land from the low peninsulas and milder districts of the south. The Himalayas ascend to the grandest heights, and in their sublime elevation crown the continental water-shed with earth's most stupendous peaks. Their passes

are little lower than Mont Blanc; their roads are dizzy shelves encircling more tremendous cliffs, or swinging *jhúlas* spanning frightful gorges, whose depths seem lost in the bowels of the earth. "There, far above the habitation of man, no living thing exists, no sound is heard, the very echo of the traveler's footsteps startles him in the awful solitude and silence that reigns in these august dwellings of everlasting snow." Deep ravines penetrate between imposing groups of inaccessible mountains, torrents hew out their tortuous courses over precipitous slopes, and the gathered influx of innumerable lines of drainage gives rise to the Indus, Ganges, and Brahmapootra, great and sacred streams whose head-waters here pursue their rocky and dangerous descent to the plains of India. Between the higher ranges nestle the fertile valleys of Nepaul, Bootan, and Assam, themselves high table-lands upon the declivity of the snowy peaks; and to the east, beneath the alternate shadows of the Hindoo-Koosh and the Himalayas, reposes the fragrant vale of Cashmere.

As we approach the mountains we traverse three distinct regions: the green "Tarai," marshy and insalubrious; the middle country, a belt of wooded land, arid and with a porous soil; and lastly, at 10,000 feet, the dry and unhealthy *marais*. The nucleal range we find is beset with numerous branches, whose long axes stretch out in waving and complicated lines from the central ridge, lie furcating and multiplying like tree-limbs as they embank the rivers, or surround occasional basins, into whose fruitful beauty the traveler peers. Clay slate, very micaceous, and passing into sandstone with interstratified limestone, forms the lithological basis of the mountains, and through the passes ramifying veins of quartz and granite. The tertiary formation extends up the valleys and laps over the foot-hills. The ascent now becomes strewed with erratic blocks, and angular bowlders of granite occur far removed from their origin, while ravines and stream-beds are picturesquely strewed with transported masses. At times the accumulation of bowlders becomes so extensive as to choke the valleys, or rise in confused piles and in unstable equilibrium for a hundred feet above the brawling streams which pass between them. The valley of the Shayuk is filled with these bowlders; and, after its waters unite with the Indus, their swollen floods pour through a narrow channel beneath enormous heaps of angular fragments. Again, about Iskardo, two banks of bowlders project upon the valley forty to fifty feet high; in fact, along the Indus immense tracts are covered with granitic masses; they lie over the alluvial land, intermixed indeed with it, and form natural features from their size. The valley of the Thawar is fairly blocked at one end by the collection of bowlders, and long hills are composed of such *débris*. For almost a day's journey on the mountain-sides, west of Pok, limestone blocks occur in great numbers, transported from indeterminate distances, as no limestone occurs here *in situ*. A glacier occurs upon the Parang Pass, not of large proportions, which, wedged between the

mountains, ruggedly advances, carrying limestone bowlders, and terminating three miles from the head of the pass in a steep precipice one hundred feet high, where its final burdens are discharged down the mountain. Snow-beds or small glaciers are of constant occurrence at the heads of the ravines, and the cool water-brooks which traverse the slopes spring from their melting edges. In Butna Valley the traveler passes for two miles among huge bowlders, then crosses a moraine, and finally reaches a plain encircled by lofty mountains, some of which reveal resplendent pyramids of snow which "bind" into a glacier, filling the head of the valley. Its surface is obscured by masses of rock and gravel, and beyond its present limits similar proofs of its ravages lie in bewildering confusion. From the valley of Nubbra the traveler beholds the encircling peaks brilliant and luminous in the blaze of countless snow-fields, while icy currents, confluent in larger glaciers, stream from the distant heights. One of these, approached through avenues of bowlders, is half a mile wide, and black with a coverlid of stones and dirt. Neighboring ravines conceal kindred masses whose extremities retire from terminal heaps of bowlders, landmarks of their former expansion. The magnificent glaciers north of Sassar are conspicuous and famous. The large glacier passes down the mountain-side, ploughing a deep furrow through an alluvial plain and plunging into the Shayuk River, whose waters eddy and boil from underneath it. Two moraines accompany it, one of enormous blocks and sixty feet high, outside of its present shrunken area, formed in the glacier's former strength, and a smaller one upon it. In furrows, fifteen and twenty feet deep, upon its surface are sunk strings of rocks imbedded in the icy matrix, and released in occasional showers from its terminal cliffs upon a talus of fragments thus accumulated. In the Shigri Valley and at Zanskar, enormous glaciers are gathered together in companies. Some are literally buried beneath the extraordinary heaps of rocks and detached slabs which are caught upon them from shattered cliff and stony avalanche. They work their way underground, while grass and flowers decorate the desolate covering which conceals them. The valleys of Thibet show unmistakably the past presence of extensive glaciers. Moraines and traveled blocks reach low down into them, often three thousand feet lower than the existing termini of the glaciers.

If, leaving the inhospitable terraces of Thibet and the sublime and unrivaled summits of the Himalayas, we traverse the ice-covered tableland of Greenland, we shall encounter the same phenomena as those we have examined in the Alps, in Norway, and in India, but so magnified in extent as to become continental, and in a measure reconstruct the picture of a world hidden beneath a universal *mer de glace*. Greenland stretches down from those vast and unexplored regions, whose limits encircle the pole, in a broad wedge-like peninsula, deeply fissured by fiords and bays, its margins abruptly rising in mural precipices, and bearing upon its bosom the oppression of an illimitable glacier. From

Cape Farewell, where Greenland rises amid a group of rocky islands, to more than 1,300 miles northward, and far beyond, where no human step has trod, a rigid sea of ice sweeps its appalling and silent surface. The ice piled up upon central axes forces itself outward in vast sheets and icy currents to the shore. This universal exudation of ice makes an ice-wall many hundred feet high along the coast, an impressive feature in that northern land, and a solemn token of the desolation it protects. At its foot a shelf of ice projects into the water, in places a smooth table, but more frequently tossed in the wild commotion of confused hummocks straining and grinding together, urged by the resistless impetus of the arctic tides.

From the wide central area descend numerous glaciers upon both the eastern and western coasts, and fimbriate by slow erosion the rock-bound land. Thus carved, in the long succession of ages, deep fiords penetrate the country, walled by lofty and inaccessible precipices, and terminating at the feet of ice-tongues which protrude their burdens of rock, gravel, mud, and soil, into their waters. In places these deposits shallow the water to great distances; and far from shore, rounded rocks, transported from interior highlands, project their polished summits above the waves. Bowlders of green-stone and syenite, rounded by friction and brought from remote localities, are scattered over wide districts. Again, upon the ice-foot which fringes the base of the cliffs, bowlders, tons in weight, are found, dislodged by frosts from the rocks above, and composed of magnesian limestone and inferior sandstones, while elsewhere long backs of rocks are seen abraded and furrowed by ice-floes and glaciers.

The glaciers occur at the indentations of the shore-line and where the cliffs decline, affording them approach to the waters. Here breaking into gigantic fragments, each one a towering iceberg, or slowly melting in the warmer waters of the sea, they constantly waste away, and are as constantly replenished from the inexhaustible and overflowing reservoirs they have left. The great conduit from the inland sea is the Humboldt Glacier, which extends its glassy wall, 300 feet high, along the deepest water for sixty miles, pouring out incalculable volumes of ice, laden and penetrated with bowlders, trophies of its resistless march from hidden and unknown recesses. Kane's Northumberland Glacier, interesting from the apparent viscosity of the ice, reaches from the interior to the coast unbroken, even when subjected to most unequal and various descents, by any fracture, while in many places "it could be seen exuding its way over the very crest of the rocks, and hanging down in huge stalactites seventy or one hundred feet long." This glacier carried enormous measures of earth, gravel, and rubbish. The Great Glacier is rifted in long shelves, which at a distance seem pressed together, the intermediate crevasses appearing as lines above one another. As the motion conspicuous in every part of this glacier successively brings these detached walls to the seas, they are floated

away in trains of icebergs, over whose sides pour streams of water, to be lost in cavities, while torrents gush down their faces, sculpturing the ice with the facile mimicry of towers, minarets, and spires. Bowlders, polished and channeled rocks, submarine moraines, abraded and excavated cliffs, are met with everywhere, and Kane counted forty-one ledges, old beaches marking the recession of the sea, which in their succession led from the granitic nucleus, formerly the coast-wall, to the present shore—all typical features of the landscape where glaciers and ice-caps are no longer found. The scenic effects in Greenland are wonderful in the extreme. Appalling cliffs rise in barren and frigid splendor from the broken floors of hummocks, and the peripheral ice-foot; their summits, corroded by frost, discharge bowlders and *débris* upon the ice beneath, while icebergs in towering and fantastic glory crowd the shallowing bays, or press along the coast in weird processions, marshaled by the shriek of the cracking floes, the crush of their own dismantled pinnacles, or the thunder of distant avalanches.

Again, turning our eyes to warmer latitudes, let us direct our explorations to New Zealand, and learn the corroborative testimony it offers for this great theory. On the South Islands of New Zealand glaciers rest among the high recesses of its western mountains, upon Mount Cook, Mount Tasman, and neighboring summits, while a glacier from Mount Tyndall, at an elevation of 4,000 feet, gives birth to the river Clyde, where its abrupt termination rears an icy wall 1,300 feet long and 120 feet high. The Francis Joseph Glacier from Mount Tasman descends to within 705 feet of the sea-level, exhibiting the characteristics of all known glaciers. These massive streams are carving with remorseless energy the solid rocks, and transporting in their course the trophies of their labor. Yet, strong and magnificent as they now appear, they are but the ghosts of those former seas which swept from peak to wave, and piled upon the flanks of the mountains and the depressions of the coast the huge moraines and the transported bowlders which appear on every hand. These heaps of *débris* and congeries of rocky fragments lie in the direct extension of the present glaciers, and indicate most strikingly their origin. Lake-basins and narrow fiords created by the erosion of prehistoric ice are universal; and Lake Wakatipu, by the most indisputable proofs, has been thus dug out of the living rock—1,400 feet deep—itself but the shrunken outline of a previous sheet of water that reached into the rock-worn valley below it. Even now the glaciers of Mount Carnslaw, the brief remains of former arctic glories, now retreated beyond the thermal influences of the lowland, emit two rattling streams, turbid with the ground powder of the rocks, which, depositing their silt at the upper extremity of Lake Wakatipu, are obliterating in made land the testimony of past ravages.

Passing in one broad stride to the opposite, the eastern margins of the Pacific, we find amid the savage and inhospitable Cordilleras of Patagonia new glaciers, and around and beneath them memorials of a

grander reign than that they now engross. Immense bowlders of basalt, sixty-seven miles distant from the nearest mountain, pebbles of porphyry, fragments of granite and slate, border the Santa Cruz River, impede its course, and lie broadcast upon the plain which rises 1,100 feet above its bed. From the encircling shores of Beagle Channel, glaciers born upon the lofty slopes and granitic peaks 4,000 and 5,000 feet above the sea, push their frozen lengths into the sea, which is shaken into waves as successive ruptures into the ice launch mimic icebergs upon its surface. "Almost every arm of the sea," writes Darwin, "which penetrates to the interior higher chain, not only in Terra del Fuego but on the coast for 650 miles northward, is terminated by tremendous and astonishing glaciers." Old channels, now dry by the elevation of the land, are diversified with groups of traveled blocks, and the bowlders, so well known, from the distant Andes, lying upon the island of Chiloe, are further indications of an action in the past identical with that exerted at present.

In conclusion, without rehearsing the evidence drawn from the Pyrenees or the Caucasus, where glaciers still exist, we see in the northern and southern hemispheres the imposing remains of primitive areas of ice which in a more congenial era projected their confluent and intermingling branches over vast regions of the earth, where, as they have retreated, they have left irrefragable evidence of their power. We have observed the same processes at work, the same results produced, the same methods utilized, in the world about us, and the clearest analogy compels us to accept a theory which ascribes the morainic *débris* piled up in hills and islands, the engraved rocks, the excavated basins, and the rounded slopes, to an identical though vastly-magnified cause in times only within the ken of Geology in its retrospective glance of ages.

SINGING MICE.

By HENRY LEE.

A FEW days ago I was invited by a medical friend to visit him at his house, and hear two musical mice sing a duet, the performance to begin punctually at 8 P. M. I had never heard a singing mouse, though I had read and been told a good deal of the vocal accomplishments the little animal occasionally displays; so I gladly availed myself of the opportunity, and duly arrived half an hour before the commencement of the concert. My friend explained to me that every evening two little mice came out from behind the skirting-board in his dining-room, and sang for their supper of cheese, biscuit, and other muscine delicacies, which he took care to place on the carpet for them always at the same hour. One of them had received the name of "Nicodemus"—an allusion, I suppose, to a certain furtive visit by

night—and the other was known as "The Chirper." To "make assurance doubly sure" that they would fulfill their engagement, and not disappoint me, their supper had been withheld from them on the evening previous to my visit.

True to time, just as the clock struck eight, and while we were conversing, there came from a corner of the fireplace, "Chirp, chirp, chirp," the same note being repeated several times at the rate of about thrice in a second, and gradually becoming louder. Presently a slight movement was visible about one end of the fender; and, after some hesitation, a little brown mouse came out upon the carpet, leisurely sniffed about for its accustomed meal, came close to my chair, looked wistfully up to my face, and I was introduced to "The Chirper." As a critic, I am bound to say that "The Chirper's" performance was of second-rate quality; but it was merely a kind of *levée de rideau*, and the principal artist was yet to appear.

We had not to wait long. At the conclusion of "The Chirper's" ineffective solo, a prolonged trill was faintly heard from behind the scenes, followed by others, each more audible than its predecessor; and ultimately "Nicodemus," the soprano, came forth before the audience, perfectly self-possessed, and showing no signs of "stage-fear."

The song to which the little creature gave utterance again and again in our full view was as sweet and varied as the warbling of any bird. It most resembled that of the canary, but the melody of the nightingale was occasionally introduced. Every note was clear and distinct, but withal so soft, so gentle, tender, and *pianissimo*, that I can only compare it to the voice of a bird muffled by being heard through a down pillow. In the room was a canary, whose cage was suspended in one of the windows. He had settled himself to roost, and his head was under his wing, but at the sound of "Nicodemus's" serenade he awoke, and listening attentively, and fantastically leaning alternately to right and left, peeped curiously down to the floor. I learned that mouse and bird were intimately acquainted with each other, and that the former frequently visited his feathered friend and staid to supper. Accordingly, while we looked on with interest and pleasure, "Nicodemus" climbed up the drawn curtains, entered the bird's cage, and partook of the seed—the canary showing no symptom of disapprobation or disturbance, but merely from his perch peering down on his visitor in a ludicrously quaint and odd manner. During his supper-time "Nicodemus" obliged us, from the cage, with several repetitions of his song, "The Chirper," down below on the carpet, occasionally coming in with a monotonous contralto accompaniment, and sometimes emitting a sound like the squeaking of a corkscrew through a cork. The two little songsters, having done their best to please us, were rewarded with all that mice could wish for as components of a feast, and, after selecting the portions they severally preferred, gracefully retired.

The singing of mice has been attributed to various causes: 1. It has been thought to proceed from disease of the lungs or vocal organs, and to be akin to the wheezing characteristic of asthma. 2. It has been propounded that the singers are always pregnant females; but this statement has been made on very insufficient data, and may, I think, be dismissed. 3. Dr. Crisp informed Mr. Buckland that he thought the singing was caused by a parasite in the liver; and Mr. Buckland tells me that he has at his museum at South Kensington a specimen in spirits in which this parasite is plainly visible in the liver of a singing mouse once alive in his possession. "But," he says, "I am not at all sure that other mice also who are not musical have not this parasite." This I believe to be the case, for it is well known that mice and rats, whether singers or not, are peculiarly liable (perhaps from their promiscuous feeding) to become the hosts of parasites such as hydatids in the liver, and trichinæ in the muscles.

Of course, I can say nothing about the condition of the livers of the two mice I heard sing last week; but they did not act as if they were afflicted with disease of the liver, or any other organ. Brisk and vivacious in all their movements, darting now and then back to their hiding-place, as if to keep open their means of retreat while foraging, they looked the impersonation of vigorous health and bright activity; and, like every one else who has heard them, I feel quite sure that their song—especially that of "Nicodemus"—is not involuntary, nor the result of any disease of the respiratory organs, but an intentional and conscious utterance of a series of notes in musical sequence. As Mr. Buckland says (*loc. cit.*), "The song is a genuine song, as good and as musical as that of a lark on a fine summer morning."

Prof. Owen tells us that the anatomy of the mouse is very similar to that of birds; and all who have seen this little rodent in the act of singing have noticed that the throbbing of its throat is like that of a bird in full song, and that it then elevates its snout as a bird does its beak.

Whether the singing of mice may be due to an imitative faculty which leads them to mimic the vocalization of birds, I am not prepared to say. There is great apparent probability in favor of this supposition, but there is, also, strong evidence against it; because well-authenticated instances have been adduced of mice bred in captivity, and apart from any caged bird, having exhibited capability of song.

It is remarkable that in almost every case of a singing mouse having been seen as well as heard, it has been described as very small, much browner than the common gray or slate-colored mouse, and as having very large ears. This exactly applies to my little entertainers, "Nicodemus" and "The Chirper." They are both very tiny mice, their coats are very brown (not so much so as to be fawn-colored), and their ears are abnormally big. I should be tempted to regard the singing mouse as a peculiar variety, if this idea had not been contra-

dicted by the recorded fact that one out of a litter of common mice has become a "cantatore" or "cantatrice," while the rest have remained incapable of "favoring with a song."

The fact is that, although singing mice are not very rare, they are not common enough to have permitted any competent zoölogist to note their birth and parentage, observe their habits in life, and dissect them after death in a series so complete as to give assurance of scientific accuracy.

I was amused on reading in a paragraph in *Nature*, of the 25th ult., that, in reply to a letter from Dr. Berdier in *La Nature*, affirming that mice sing, "a distinguished herpetologist, M. Lataste, suggested that Dr. Berdier might have made confusion with the singing of a raniform batrachian, the *Bombinator igneus;* but Dr. Berdier said there was no marshy ground near the room in which he had heard it, and he stuck to his assertion." There certainly was no "raniform batrachian, *Bombinator igneus*," in the comfortable dining-room in Gower Street, where I was introduced to "Nicodemus" and "The Chirper," and one would suppose that the instances of mice having been seen, as well as heard, singing, have been sufficiently numerous and well attested to render unnecessary so extravagant an explanation as that of the "distinguished herpetologist." The subject was, however, regarded as worthy of being brought before the Société d'Acclimatation at its last meeting, when M. Brierre confirmed the observation of Dr. Berdier, and stated that he had himself heard mice sing, though not more recently than 1851–'53.—*Land and Water.*

SKETCH OF WILLIAM SPOTTISWOODE.

WE in the present number of the MONTHLY offer to our readers a portrait of Mr. William Spottiswoode, F. R. S., D. C. L., LL.D., President of the British Association for the Advancement of Science, at its late session in Dublin.

WILLIAM SPOTTISWOODE is the son of Andrew Spottiswoode, M. P., printer to the Crown and the House of Lords, and prominent in the history of printing for his earnest encouragement of every invention tending to perfect that important art. The son was born in London, January 11, 1825. Having studied successively at the famous public schools of Eton and Harrow, winning high honors at the latter institution, he in 1842 entered Balliol College, University of Oxford, and three years later graduated A. B. as a first-class in mathematics. He had already made considerable progress in that particular branch of knowledge, and in 1837 and the following years had printed for circulation among his friends "Meditationes Analyticæ." He has ever since

followed with keen interest the progress of mathematical research, and is an active member of the Mathematical Society of London. In 1846 and 1847 he gained mathematical scholarships at Oxford.

But the death of his father, occurring in the latter year, devolved upon Spottiswoode the active superintendence of a great printing establishment, and henceforth he could devote to his mathematical and other studies only his leisure time ; nevertheless, in sundry departments of learning and science Mr. Spottiswoode has rendered eminent service, at the same time taking an active part in movements having for their end the promotion of popular education and the social and material improvement of working people.

His favorite studies, besides the mathematics, are, in physical science, light-polarization, to the explanation of which his experimental researches have greatly contributed ; languages, both European and Oriental, but especially Sanskrit; and certain departments of philosophy. Of his philosophical power and insight we have abundant evidence in the elaborate discourse addressed to the British Association in Dublin last August. (It is published in the POPULAR SCIENCE MONTHLY SUPPLEMENT for October.) Mr. Spottiswoode is Honorary Secretary of the London Royal Institution, and charged with the duty of arranging its winter courses of lectures on science, art, literature, etc. He frequently lectures in these courses himself, taking that means of bringing before the world the results of his scientific studies. His printed works are "Meditationes Analyticæ ;" "A Tarantasse Journey" (1857), giving an account of a visit to Eastern Russia; and "Polarization of Light" (1874). He was Treasurer of the British Association from 1861 to 1874, of the Royal Institution from 1865 to 1873, and of the Royal Society from 1871 to 1878, in all these positions happily combining the prudent economy of the man of business with the open-handedness of the lover of science. He has been nominated by the Council of the Royal Society to succeed Sir Joseph D. Hooker in the presidency of that eminent scientific body. Mr. Spottiswoode was elected Corresponding Member of the Paris Academy of Sciences in 1876, and honorary degrees of LL.D. and D. C. L. have been conferred upon him by the Universities of Oxford, Dublin, and Edinburgh. He is a member of nearly all of the great scientific societies of England —the Astronomical, Geographical, Asiatic, and Ethnological, and of the Society of Arts. He was Public Examiner in Mathematics at Oxford in 1857–'58, and has acted as an examiner under the Civil Service Commissioners ; also for the Society of Arts and the Middle-Class Schools. He has always been a liberal patron of makers of philosophical instruments, and has thus promoted many an ingenious invention.

CORRESPONDENCE.

ELEMENTARY SCIENTIFIC INSTRUCTION IN GERMANY.

To the Editor of the Popular Science Monthly.

THE following communication, signed Charles A. Duvoisin, and published in a French journal, will no doubt be welcome to your readers, especially such of them as take an interest in the scientific education of the young. B.

Is it not strange that teachers of natural history, in most countries, have utterly overlooked the very effective practical scientific instruction which the pupils of Latin and commercial schools receive already at a very early age? I refer to the excursions which German teachers of science make every week, into the environs of the cities where the above-mentioned institutions are located, with their classes, and to the encouragement given to the pupils to make collections of interesting natural objects. There is a regular system followed in this respect, and I declare that its results are in every way excellent. Let me give here an account of what I saw in the city of Rostock, the largest city in the grand-duchy of Mecklenburg-Schwerin, and an import seaport on the shores of the Baltic. That city has a Latin school, or, as they call it in Germany, a gymnasium, whose seven classes are visited by three hundred pupils, in round numbers, and a commercial school (*Realschule*), with an equally numerous attendance. In the fifth class of the gymnasium the boys, who, on an average, are eleven years old, are taught the rudiments of entomology. Why entomology? Because the teacher goes out with them every afternoon and hunts, in the woods and fields of the environs, beetles, bugs, and butterflies. Every pupil has with him a small bottle, filled with alcohol, into which he drops the insects he catches, and a butterfly-catcher, the victims of which are confined in a tin-box fastened to the pupil's leather belt. The teacher instructs the boys where to look for beetles, and he not only gives them the Latin names of those they find, but describes to them their peculiarities, calls attention to their beauties, and tells his hearers whether they are rare or very common. When one of the boys is told that he has found a very rare specimen, he feels as happy and proud as a king. I accompanied the little fellows one Saturday afternoon on one of these excursions. It was a pleasant July day, sunny, but by no means sultry. The environs of the city consist of oak-forests and extensive meadows. The roads were rather sandy. All the boys were on the alert for those wonderful beetles, the *cicindela*. They were hard to catch, but about twenty of them were bagged, or rather bottled up. To my amazement I found that these eleven-year-old boys were able not only to give the names of every species of *cicindela*, but also to point out their distinctive marks. For four hours we roamed over meadows and wooded hills. Everywhere new specimens were hunted for in their hiding-places, and secured. At last the boys were tired. They sat down on the mossy ground of a pine grove, partook of the sandwiches they had brought with them, and sang a stirring song. And then ensued a strange sort of fair. The boys began to trade off a *cicindela* for a *scarabæus*, etc. "What are they doing this for?" I said to the teacher. "To complete their entomological cabinets," he replied. "What?" I asked. "Have these little fellows regular collections of entomological specimens?" "Have they?" laughed the teacher. "There is not one of them but has his cabinet, and in not a few of them the entomological fauna of this part of Germany is very creditably represented." I could not help thinking that all this was most excellent and praiseworthy. The excursions are splendid for the health of the pupils. They learn in them practically what many students of colleges can acquire only by the hardest of toil, and even then imperfectly, and the collections of beetles and butterflies at home keep the boys out of a great deal of mischief. In the fourth class of the gymnasium they teach zoölogy and mineralogy. I was assured that the largest menageries visited the city, and that the pupils of the gymnasium were among their most frequent and intelligent visitors. Nearly all of them had mineralogical cabinets, and I was astonished to find not a few of the latter filled with the most valuable and scientifically arranged specimens. Botany is the special study of the third class of the gymnasium. The system of excursions for the collection of flowers and plants is most religiously pursued, and the consequence is that all the pupils have *herbaria* well stocked and well classified. In the two highest classes of the gymnasium the remaining divisions of science are taught. Not a few of the pupils have excellent physical cabinets, and some

of them have even chemical laboratories which many a professional chemist would not despise.

Now, is not all this truly admirable and worthy of imitation? Is it a wonder that we find among the Germans so many scientific specialists, so many laymen taking the liveliest and most intelligent interest in scientific researches, so many journals devoted to popular science? What do we have in France instead of all this? Only a few dry scientific lessons a week, which repel rather than interest most of the pupils of our lyceums. Those who achieve eminence in science afterward have to learn their rudiments in natural history at the colleges, and then to possess not only a natural proclivity, but also special gifts for that kind of study. England is in this respect still worse off than we. The best proof of this is to be found in the fact that, whenever that country sends out a scientific expedition, most of the branches of research have to be intrusted to German *savants*. May our government, which I know to be animated with the earnest desire of perfecting our system of instruction in our lyceums, turn no deaf ear to my humble voice. Let us learn from our powerful neighbors in Germany. They appreciate the value of early practical and theoretical instruction in natural science. True, they have not so brilliant a galaxy of scientists as we have in Paris; but the knowledge which their youngest pupils possess in natural history far surpasses that acquired in our lyceums.

EDITOR'S TABLE.

COFFEE-HOUSES AGAINST RUM-SHOPS.

THE contrasts of the deductive and inductive habits of mind are seen in philanthropy as well as philosophy, and give rise to two schools of reformers. What we may call deductive reformers start from general principles, and many of them never get much further. Reformers of this stamp are apt to be impracticable. Whether their plans can be carried out, or what the results may be, concerns them much less than the soundness of the postulates. If the cause be right, and the evils and wrongs attacked are undoubted evils and wrongs, they hammer away at them, generation after generation, regardless of anything except that they are in the line of their duty. This school has no patience with expediency, which seeks for the best thing under the circumstances, because it abhors the philosophy of circumstances, and will never compromise high principles. Reformers of this type generally work with the tongue rather than the hand, and their crusades are for the dissemination of their doctrines. They may do a great deal of good, but there is a great deal of practicable good that they certainly fail to do.

There is another class of reformers whose habits of thought are more inductive, viz., they study the facts first, perhaps make trial or experiments with them, allow for conditions, aim at attainable ends, and form their conclusions on the basis of experience. They may have just as decisive views in regard to abstract rights and wrongs as the opposite school; but, as the world is constituted, they think that wisdom consists in following expedient and practicable courses by which actual results can be reached. They therefore take into account many considerations which the other party ignores, and are apt to be looked upon as temporizing, makeshift, and patchwork philanthropists.

These two attitudes of mind are well illustrated in the temperance reform. A large party has been striving for half a century to eradicate the evils of intemperance by proclaiming certain great inflexible principles and insisting upon their being uncompromisingly carried out. Immense evils result from the use of alcoholic drinks as beverages, and it has been thought to extirpate these evils by reprobating the use of anything alcoholic under any circumstances, and by outlawing the commerce in these beverages. The rum-shops have been denounced, and the

politicians have been called upon to suppress them. Much good may have been done; but drinking habits are still prevalent, and rum-shops still abound. The temperance reform, from this point of view, has been a failure, if by success we understand the eradication of the evils of intemperance. This failure has been, we think, at least partially due to the refusal of the master-minds of the movement to study the various ways in which partial advantages may be gained. Those who view the subject practically maintain, for example, that much benefit to the community would result if the weaker liquors could be generally substituted for the stronger, as wine and beer for distilled spirits; but this notion has been sternly resisted by the great mass of ardent temperance reformers as sacrificing first principles. All alcoholic liquors, they maintain, are poisonous, baneful, and to be equally condemned, unless, indeed, the weakest are not the most dangerous. To which the reply is, that these extreme views are self-defeating; that they have been preached until the community is wearied with it, while the liquor traffic still flourishes, and that it is the part of wisdom to check, diminish, and circumscribe an evil where it cannot be wholly removed. Something might, therefore, be gained, they maintain, by substituting wines and beers, containing five or ten per cent. of alcohol, for whiskey and rum containing forty or fifty per cent.

However this may be, of one thing there can be little doubt, that to substitute the use of tea, coffee, and cocoa, for spirituous liquors, would be a great gain. In the literature of teetotalism thus far there has been but one dietetical alternative to alcohol, and that is water. With curses upon alcoholic drinks, the temperance lecturer has interspersed copious praises of "clear, cold, sparkling water." In practice the abandonment of alcoholic stimulation has been often accompanied by a resort to the stimulations of opium and tobacco—a change which has in it but few elements of reform. As an ultimate fact of man's nature, he is so constituted that he seeks stimulus of some kind—some method of breaking the monotony of the feelings and getting contrasts in the psychical life. This may be wrong, and water may be the drink that should be exclusively patronized by everybody; but that consummation, whether desirable or not, is undoubtedly remote, very remote indeed. Meantime, there would unquestionably be a great gain in substituting tea, coffee, chocolate, and cocoa, for alcoholic liquors.

Accordingly we are glad to see that a vigorous movement has been set on foot to fight rum-shops with coffee-houses. We have received a very interesting tract from Mr. Charles Collins, describing the results of experiments made chiefly in Liverpool, to maintain a system of "public coffee-houses" and "cocoa-rooms" for the use of English laboring men. There is a society in Liverpool for the promotion of this object, and the pamphlet before us is made up from its reports.

It appears that twenty-nine places under the denomination of "cocoa-rooms" have been opened in Liverpool under the auspices of this society, by the employment of a subscribed capital of $100,000. So successful has been the enterprise, not only in its favorable influence upon the habits of the people, but also pecuniarily, that ten per cent. profit on the investment was distributed to the stockholders last year, and it is now proposed to increase the capital of the association to $200,000, in order to still further extend its operations. The following are some of the most important suggestions of the company in regard to the management of such places, as arrived at by their own experience:

"1. It is necessary to provide accommodation for the working-classes, men and

women, on the same principle as the public-house—free admission to all, a cordial welcome, and no more restraint than is required for the orderly conducting of the house.

"2. It is desirable to have the ground-floor open on the street level, not up several steps; and in the front shop space for a bar, conveniently placed for customers, within which the manager and attendants are to be found. On the counter will stand the large tins, holding from six to ten gallons, and kept hot by gas ring-burners underneath. Behind the bar there should be a sideboard with shelves for the cups, mugs, and other utensils, and also for the rolls, cakes, etc. Here also will be found convenient hot-water troughs for washing the crockery immediately after being used.

"3. The other parts of the room should be furnished with benches and tables, according to the available space; the benches are found most convenient 7 feet in length with backs, the tables, when of strong plain deal, 6 feet long by 15 inches wide; when marble top, 4 feet by 22 inches.

"4. If there are other rooms to be furnished, tables of the same kind are recommended, but in some cases strong Windsor chairs are found more convenient than benches.

"The premises ought, as far as possible, to be taken in a locality convenient to the largest number of workpeople. Attention should be paid to the thoroughfare, and the facility of access. Back streets or quiet neighborhoods, even where rents may be cheaper, will not answer the purpose.

"6. The houses should be as nice as possible—cheerful in appearance, clean, airy, and with sufficient space for customers to approach the bar, and to sit down to eat and drink at the narrow tables.

"7. The manager should be one who has the work at heart—to throw some spirit into it, and aim at success. He should be willing to take any trouble, and do what he can to please his customers. He should be bright, pleasant, friendly, not easily provoked, but able to take chaff from rough customers without offense. Withal he must be reliable for integrity, and must try to make his influence felt by force of example rather than by law.

"8. The other attendants are embryo managers, and should be trained to the same qualities. If female attendants are employed, they must be especially discreet, as no familiarity should be allowed; they should also be clean and tidy in their person. Proper attention should be paid to the hours of service, so that no undue strain be put upon willing workers. The plan of relays of servants meets the case of early and late hours.

"9. As the cocoa-room movement is an effort to counteract the evil of drunkenness and the baneful influence of the public-house, it is essential that those in the employ be *bona fide* 'abstainers.' No spirits or alcoholic drinks of any kind are allowed to be sold or consumed on the premises.

It may be added that the rooms are open to all at five in the morning, so that men may call on their way to work, as the early morning cup of hot cocoa, coffee, or tea, is found to be of immense advantage. It is said that many by this means have been saved entirely from the use of other stimulants. The cocoa, coffee, and tea are of good quality, and are furnished hot at the following prices: two cents per large mug and one cent per small mug of cocoa and coffee; tea, two cents per cup. The large mug contains a pint, the small mug and the cup contain each a gill. Newspapers are provided for reading, smoking is allowed for those who wish to indulge in it, and separate rooms for women are said to have been much appreciated. All the arrangements have been placed on a business footing, and with an eye to profit.

There is an association in London for the promotion of a similar object, and in their circular, entitled "The Coffee Public-house: how to establish and manage it," they say:

"Give the workingman a public-house, where he may meet his friends, and talk and smoke, and play games with all the freedom to which he has been accustomed, and where good coffee and tea—with stimulus and nourishment in them—take the place of beer and gin, and you set before him for the first time, plainly, the choice between sobriety and comfort on the one hand, and dissipation and wretchedness on the other. If it is proposed to carry on mission-work, it is better that this should be done in adjoining premises, rather than in the coffee public-house itself.

"The rooms should be airy and pleasant, full of light and color. It is better to avoid

giving to the coffee public-house a distinctively class designation, or one which might appear to connect the house with any particular social or philanthropic movement.

"The plan of partitioning off portions of the ground-floor, or setting apart rooms for reading, smoking, or other purposes, though occasionally useful, does not always work well. Men like being in a crowd; isolation is not to their taste; and an arrangement of this kind is apt to lead to overcrowding of particular rooms while others may be almost unoccupied. The only other exception to the foregoing rule is where a room can be set apart for the accommodation of women and children, or for youths. Wherever a room especially for women has been opened, as in some of the Liverpool houses, the boon has been highly appreciated. It should be understood that men accompanied by their wives may use the women's room, and every encouragement should be given to men who may be disposed to bring their wives and children to the coffee public-house. Women should be encouraged to avail themselves of the public rooms when no other accommodation has been provided for them."

There is everything to commend and nothing to condemn in this mode of promoting the work of temperance. It proceeds upon the assumption that there is no use in trying to shut up dram shops until something else has been provided to take their places. Various causes lead to the formation of intemperate habits, but perhaps the most powerful are social influences. Men are gregarious, and as they are cultivated they become more social and crave companionship. They meet together, and wine favors geniality and conviviality. If men are to be delivered from this temptation, they must be furnished with a substantial equivalent, or places where they can come together and have *some* social enjoyment without the temptation of intoxicating drinks. Reform here begins at the right end. Its spirit is not ascetic, but sympathetic, and it cannot fail to be well received by large numbers who would not be influenced by bare moral inculcations.

It is to be hoped that the experiment that has proved so successful in Liverpool will be tried in New York and other American cities, under such modifications as the changed circumstances may call for. The desirableness of some systematic movement of the kind is undoubted; and if it will do positive good, and pay its expenses and yield a liberal profit, there ought to be no difficulty in getting capital for it, whatever may be the difficulty in finding competent and trustworthy managers, who will not steal the funds.

THE PROGRESS OF RATIONAL EDUCATION.

It is often impatiently asked whether the world is really making any advance in more reasonable views of mental cultivation. The old errors live on with such a persistent vitality, after they seem to have been cut up by the roots, that the question is naturally raised whether this is a sphere in which common-sense has any chance against tradition and superstition. Yet there are many indications of a decided and healthful progress in the direction of greater liberality and the increasing control of enlightened principles. Take, for example, the matter of discipline. It has long been the pretext for conserving whatever is old and established in the schemes of academic and collegiate study. Greek, Latin, and classical studies must be kept in the ascendant because of their unrivaled and exclusive potency in mental discipline. The sciences and practical studies must be resisted and repressed to give scope for those venerable studies that have such a wonderful efficacy in disciplining the mind. When it is proved that this is a groundless claim—when it is shown that the discipline afforded by classical study is grossly defective, that it leaves some of the most important parts of the intellect not exercised at all, and when it is proved that modern science has high claims on still broader disciplinary ground, what does it seem to avail?

Classical studies are still determinedly urged on the ground that they afford the best possible training of the mind. It must not be inferred from this that the truth fails to make headway. There are plenty of signs that this old pretense is becoming more and more rated at what it is actually worth. Books on education now treat the subject very differently from what they did twenty years ago, and one of the objects of Mr. Bain in the important work he is now preparing on Education as a Science, is to bring modern psychology to bear upon this doctrine of discipline, to expose its fallacies, and place it upon a more rational basis. The London *Times*, that steady-going organ of British conservatism, which never moves forward except as it is moved by the progress of public opinion, is beginning to yield on this question. It turns from the English universities to the British Association for the Advancement of Science, and eulogizes its educational influence, making, at the same time, the important concession that "Physical science affords an admirable means of mental training in schools." There is certainly nothing new in the proposition, and it is no more true than before because the *Times* has indorsed it; but the declaration is a significant index of the progress of educational ideas.

Another pertinent illustration of the active spread of rational views upon this subject is at hand. *Scribner's Monthly* for September had an excellent article on the waste of effort in education, taking the ground of Spencer in his book, that it is still the college rule to sacrifice the useful to the ornamental in cultivating the minds of youth. The views of the writer are decided, but he seems to be a good deal discouraged in regard to the hope or prospect of much amendment. He says: "Mr. Herbert Spencer's views of education, as contained in his book on that subject, now for some years before the public, ought by this time to have made some impression, and worked out some practical result. We fear, however, that it has accomplished little beyond giving to a wise man, or woman, here or there, a shocking glimpse into the hollowness of our time-honored educational systems." This fear is hardly well grounded. The exposure of the defects of the existing systems of education is but a small part of the service to society done by Mr. Spencer in the preparation of his work. Its main and eminent value is in the principles it lays down for the shaping of better methods of culture. Its chief value is in pointing out the way to essentially improve methods of study. This is strikingly shown by the fact that the book has been translated into the different languages of Europe, in nearly all cases either by or at the instance of men who have been officially engaged in the work of forming and carrying out systems of public education.

There was lately published in London an expensive, two-volume work, entitled, "Twenty Years' Residence among the People of Turkey: Bulgarians, Greeks, Albanians, Turks, and Armenians. By a Consul's Daughter." The Messrs. Harper have republished this very instructive work at fifteen cents, and so we bought it and read it. Chapter XIX. is devoted to education among the Greeks and Bulgarians, and it is very interesting. After noticing some of the girls' schools, she proceeds to describe an institution, the marked superiority of which so surprised and interested her that she gives a very full account of it, from which we extract the following:

"I also visited another Greek school at Salonica, which was under the direction of a Greek gentleman educated in Germany, who has designed a new educational system, which, having had a fair trial, will eventually be adopted in all the educational establishments of the Greeks. The origin of the institution does not date further back than two years, and of all the schools I have

visited here and elsewhere, this certainly struck me as being the best and most perfect of its kind. The children were divided into classes, each of which was examined by the master, the result of which greatly surprised myself and some friends who were present. The director, who justly took great pride in his work, assured us that all these boys under his care (whose ages did not exceed eleven), in consequence of the quickness, facility, and ability with which they received his instructions, had learned in one year what he had been unable to teach in double that space of time to children in Germany. He added that he was constantly called upon to answer a shower of questions and remarks made by the pupils on the theme of the lesson, which having explained, he allows them time and liberty to discuss the difficult points, until they have quite mastered them. On their first entrance they appear listless and uninterested; but, as the love of knowledge is developed and grows upon them, they often, when school-time is up, beg permission to remain an hour longer in class."

This was certainly a curious phenomenon to stumble upon among the barbarians. We recommend the troubled school-hunters, of whom there seem to be many who can find nothing satisfactory at home, to send their children to Salonica—the missionaries will convoy them.

Deeply interested in what she saw, and being of a turn of mind to look into causes and seek explanations, she desired to inform herself further in regard to the methods of this Greek teacher, and remarks:

"Very much pleased with all I had seen and heard in this establishment, I begged the director to let me have one of the class-books containing the routine of teaching. He replied that he had no special work on the subject to abide by, and that the routine of lessons, left to his own judgment, had been combined by him partly from the system he had studied in Germany, and partly from ideas suggested to him by reading the philosophical works of Herbert Spencer, for which he appeared to have a great admiration."

The writer in *Scribner's Monthly* should, therefore, feel encouraged. If "a new educational system, which, having had a fair trial, will eventually be adopted in all the educational establishments of the Greeks," has been specially moulded by ideas derived from Herbert Spencer, it will be no longer possible to say that his work is without practical result.

LITERARY NOTICES.

SCIENTIFIC MEMOIRS. Being Experimental Contributions to a Knowledge of Radiant Energy. By JOHN WILLIAM DRAPER, M. D. Harper & Bros., 1878. Pp. 473. Price $3.

THOSE who read the concluding paper of Dr. Montgomery in the October POPULAR SCIENCE MONTHLY, on the present aspects of the "Problem of Life," will remember the admirable terms in which he refers to a discovery of Dr. J. W. Draper, which seems to have a most important bearing on this subject. Though made many years ago, it is only now beginning to be appreciated in its full significance. The last generation has been especially devoted to the cultivation of the sciences of radiant energy and of that plastic, protoplasmic material out of which the fabrics of all life are spun; Dr. Draper anticipated the developments that were to take place in these fields of inquiry by first determining, thirty-four years ago, what ray of the solar spectrum takes effect upon the green parts of plants to decompose carbonic acid—the initiative and fundamental change that maintains all life processes. He was the first to decompose carbonic acid by exposing leaves to the sun in the actual spectrum, and to prove that it is the yellow ray that produces the change.

The history of science contains many interesting illustrations of the appearance of men of rare and exceptional genius, whose thoughts pierce the future, and who spend their intellectual lives far in advance of their contemporaries. They are the men who lay foundations upon which others build, who carve the great outlines of research which other men come to fill up with details, who open paths of inquiry which other men pursue to their maturer results. Dr. Draper is one of these broad original thinkers whose work has contributed largely

to mark and to make an epoch in science. Early trained in chemistry, physics, and physiology, he pursued these subjects as an investigator, not only separately, but in their intimate and complex interactions, reading the mysteries of life by the light of chemical and physical principles. From 1836, onward for fifteen years, Dr. Draper conducted a comprehensive series of researches in the general field of radiant energy in its chemical relations which had been at that time but little explored. His elaborate papers giving shape and direction to this subtile research were published in American and foreign periodicals, and won the cordial applause of his appreciative co-workers in the same fields. Recognizing that he was a good deal in advance of his time, and that years must elapse before the significance of his results would be understood, he wisely collected his papers and had them published in a quarto volume, fully and clearly illustrated. An edition of this work was printed, but the expensive stereotype plates were destroyed in the great conflagration of Harper's establishment, so that no more volumes could be produced. With the recent progress of the subjects to which it was devoted, there has been an increasing demand for copies of the work, which consequently arose in price, and were prized by all who possessed them. In these circumstances Dr. Draper has thought it best to reproduce some of the most important papers, and they are now embodied in this volume of memoirs. In this he has but done an act of justice to himself and to American science, while his volume will prove of lasting interest as a contribution to the history of a most interesting and important branch of scientific inquiry, which is now undergoing rapid development, and will continue to be zealously cultivated in the future.

As to the special subjects considered, Dr. Draper's statement of them in his preface is so much better than any we could make that it is here subjoined:

"Among many other subjects treated of in these pages, the reader will find an investigation of the temperature at which bodies become red-hot, the nature of the light they emit at different degrees, the connection between their condition as to vibration and their heat. It is shown that ignited solids yield a spectrum that is continuous, not interrupted. This has become one of the fundamental facts in astronomical spectroscopy. At the time of the publication of this Memoir, no one in America had given attention to the spectroscope, and, except Fraunhofer, few in Europe. I showed that the fixed lines might be photographed, doubled their number, and found other new ones at the red end of the spectrum. The facts thus discovered I applied in an investigation of the nature of flame and the condition of the sun's surface. I showed that under certain circumstances rays antagonize each other in their chemical effect, and that the diffraction spectrum has great advantages over the prismatic, which is necessarily distorted. I attempted to ascertain the distribution of heat in the diffraction spectrum, and pointed out that great advantages arise if wave-lengths are used in the description of photographic phenomena. I published steel engravings of that spectrum so arranged. I made an investigation of phosphorescence, and obtained phosphorescent pictures of the moon. Up to this time it had been supposed that the great natural phenomenon of the decomposition of carbonic acid by plants was accomplished by the violet rays of light, but, by performing that decomposition in the spectrum itself, I showed that it is effected by the yellow. Under very favorable circumstances, I examined the experiments said to prove that light can produce magnetism, and found that they had led to an incorrect conclusion. The first photographic portrait from the life was made by me; the process by which it was obtained is herein described. I also obtained the first photograph of the moon. I made many experiments on and discovered the true explanation of the crystallization of camphor toward the light. When Daguerre's process was published, I gave it a critical examination, and described the analogies existing between the phenomena of the chemical radiations and those of heat. For the purpose of obtaining more accurate results in these various inquiries, I invented the chlor-hydrogen photometer, and examined the modifications that chlorine undergoes in its allotropic states. Since in such researches more delicate thermometers are required than our ordinary ones, I entered on an investigation of the electro-motive power of heat, and described improved forms of electric thermometers. In these memoirs will be found a description of the method made use of for obtaining photographs of microscopic objects, together with specimens of the results In a physiological digression respecting interstitial movements of substances, I examined the passage of gases through thin films such as soap-bubbles, and the force with which these movements are accomplished, applying the facts so gathered to an explanation of the circulation of the sap in plants, and of the blood in animals Returning to an inquiry as to the distribution of heat and of chemical force in the spectrum, I was led to conclude, in opposition to the current opinion, that all the colored spaces are equally warm; and that, so far from one portion—the violet—being distinguished by producing chemical effects, every ray can accomplish special changes. This series of experiments on radia

tions is concluded in this volume by an examination of the chemical action of burning-lenses and mirrors."

The volume is well printed in clear type, on good paper, and contains a fine steel portrait of Dr. Draper—much the best likeness of him that we have ever seen. It contains various woodcuts to illustrate experiments which the reader will find a useful accompaniment to the text.

Handbook of Modern Chemistry, Inorganic and Organic, for the Use of Students. By Charles Meymott Tidy, M. B., F. C. S. Philadelphia: Lindsay & Blakiston. Pp. 780. Price, $5.

This seems to be a very good practical treatise on chemistry, for the use of students in colleges and laboratories. It is well condensed, and judiciously classified. The author says concerning the work:

"I venture, therefore, to plead my apology for the publication of these outlines of chemistry. Within three months of graduating—in other words, when 'fresh from the schools'—I was appointed Joint-Lecturer on Chemistry with the late Dr. Letheby, at the London Hospital, consequently my first lecture-notes were prepared when familiar by practical experience with the wants of a student. Year by year these notes have been added to, and, to some extent, rewritten; nevertheless, except in a few instances, I have strictly adhered to the general plan I first adopted. I submit these lecture-notes to the profession as the joint experience of a student and a teacher."

Sound: A Series of Simple, Entertaining, and Inexpensive Experiments in the Phenomena of Sound, for the Use of Students of Every Age. By A. M. Mayer, Professor of Physics in the Stevens Institute of Technology. New York: D. Appleton & Co. Pp. 181. With numerous Illustrations. Price, $1.

This volume is the second in Prof. Mayer's "Experimental Science Series for Beginners," the first volume of which, that on "Light," appeared a few months ago. The "Experimental Science Series," as the author states, originated in the earnest and honest desire to extend a knowledge of the art of experimenting, and to create a love of that noble art which has worked so much good in our generation. All attempts, however, to extend the knowledge of experimental science will fail unless these endeavors on the part of scientific men are seconded by our teachers; hence Prof. Mayer while writing these books, has been constantly actuated by the desire *to assist teachers to become experimenters.* "These little books," Prof. Mayer remarks in his preface, "will show how many really excellent experiments may be made with the outlay of a few dollars, a little mechanical skill, and *patience.* This last commodity neither I nor the school can furnish. The teacher is called on to supply this, and to give it as his share in the work of bringing the teaching of experimental science into our schools. When the teacher has once obtained the mastery over the experiments, he will never after be willing to teach without them; for, as an honest teacher, he will know that he cannot teach without them. Well-made experiments, the teacher's clear and simple language describing them, and a free use of the blackboard, on which are written the facts and laws which the experiments show—these make the best text-books for beginners in experimental science. Teach the pupil to read Nature in the language of experiment. Instruct him to guide with thoughtfulness the work of his hand, and with attention to receive the teachings of his eyes and ears. Youths soon become enamored of work in which their own hands cause the various actions of Nature to appear before them, and they find a new delight in a kind of study in which they receive instruction through the doings of their hands instead of through the reading of books. The object of this second book of the series is to show how to make a connected series of experiments in sound. These experiments (a hundred and thirty in number) are to be made with the cheapest and simplest apparatus that the author has been able to devise, and they have been arranged so that one leads naturally to the making and understanding of the next." And it must be added that much of the apparatus needed for making the experiments is such that the student himself may construct it at trifling expense. So much for the method and principle of the work—a method which compels the student constantly to employ his own mental faculties of comparison, generalization, etc., and to be, in fact, a discoverer of the truths of science, not a mere passive recipient of instruction.

Unless the teacher is more than ordinarily stupid, and addicted to the routine of book-teaching, the pupil can hardly fail to have his mental stature increased, his reasoning powers strengthened, by going over the course of experiments here laid down. Of the author's success in carrying out this scheme, the first volume of the series was evidence; and our readers can see from the copious extracts which we elsewhere publish in the present Monthly that the promise made in the preface is more than fulfilled in the body of the work. Prof. Mayer's text leaves nothing to be desired in point of clearness, and, where the imperfection of written speech might cause obscurity, the illustrations, which are all new and rigorously exact, will serve to guide the reader aright.

Proceedings of the Eleventh Annual Meeting of the Free Religious Association (1878). Boston: The Free Religious Association. Pp. 90. Price, 40 cts.

Besides the financial reports and the list of officers for the ensuing year, this volume contains several more or less elaborate addresses, among which may be mentioned an essay by Thaddeus B. Wakeman, entitled "The Religion of Humanity," in which the author explains what that religion is, and shows how it may be organized and cultivated upon American soil; also, an essay by William H. Spencer: "Religion of Supernaturalism; why it should be disorganized, and how it may be done."

Annals of the Astronomical Observatory of Harvard College.—Photometric Researches. By C. S. Peirce. Made in the Years 1872–1875. Leipzig: Wilhelm Engelmann. Pp. 181. With Plates.

Of the five chapters into which this elaborate work is divided the first treats of the sensation of light; the second, of the numbers of stars of different degrees of brightness; the third is a record of the author's original observations with the astro-photometer of Zöllner; in the fourth, the star-magnitudes given by the different observers are compared; and the fifth treats of the form of the galactic cluster.

In the Wilderness. By Charles Dudley Warner. Pp. 175. Price, 75 cts.

If you cannot compass a trip to the Adirondacks, this inimitable little volume of forest sketches is a capital substitute, for Mr. Warner brings to his work a love of the woods and a knowledge of their varied features, rivaling that of "Old Mountain Phelps" himself. Moreover, subtile humorist as he is, he cannot escape being funny, and his little volume sparkles with delicate wit and keen but not unkindly satire from beginning to end.

Metric Weights and Measures for Medical and Pharmacal Purposes. Washington: Government Printing-Office. Pp. 40.

In the Marine Hospital service, medical officers are now required to employ metric weights and measures for all medical and pharmacal purposes, and in this little pamphlet are contained rules and tables for the conversion of quantities according to apothecaries' weight and measure into quantities according to the metric system. The work will interest physicians and pharmacists, and will probably be of service in hastening the general adoption of the metric system in the United States.

Sound and the Telephone. By C. J. Blake, M. D. Pp. 12.

In this paper, which was read before the British Society of Telegraph Engineers, the author states in part the result of experiments made for the purpose of measuring the vibrations of the disks of the Bell telephone, and determining the loss of power sustained in the transmission of sound. He further compares the vibrations of the telephone-disk with those of the human tympanum membrane.

American College Directory (1878). St. Louis: C. H. Evans & Co. Pp. 111. Price, 10 cts.

This volume contains a list of all the colleges, seminaries, special schools, etc., in the United States, and gives in brief much essential information concerning each; for instance, the number of teachers and pupils, number of volumes in the library, value of scientific apparatus, value of buildings, etc.

Annual Report of the New York Meteorological Observatory (1877). By D. Draper, Director. Pp. 32.

An important feature of this report is Mr. Draper's remarks upon the rainfall of New York City. It has been found by observation that there was an *increase* of rain from the date of commencing the observatory records till 1869, and after that year a steady decrease. The question now arises, "Does the rainfall of New York still diminish, will it continue to do so, and does this variation occur in the early or late portion of the year?" To which the author replies that from his study of the subject "it appears that the rainfall of this city will most probably continue to decrease by fluctuations for several years to come, and that the variations are nearly the same in the two portions of the year."

The Former and Present Number of our Indians. By G. Mallery. From "Proceedings of the American Association." Pp. 27.

Some Common Errors respecting the North American Indians. Same author. From "Bulletin of the Philosophical Society of Washington." Pp. 6.

The errors here exposed and corrected by Mr. Mallery have regard first to the *color* of the aborigines: they are *not* "red," nor "copper-colored." Their real prevailing color is *brown*. Second error: the opinion that the Indian believes in a "Great Spirit." Their common religious system is "polydemonism." Third error: that the aboriginal race is rapidly becoming extinct; the author holds that they are rather on the increase.

Opening of the Lewis Brooks Museum, at the University of Virginia, June 27, 1878. Richmond: Printed by order of the Board of Visitors. Pp. 60.

The University of Virginia is indebted to the late Lewis Brooks, of Rochester, New York, for the fine Natural History Museum—building and specimens—which was opened during the present year. The pamphlet before us gives a brief history of the founding of the institution, and contains an address on "Man's Age in the World," by James C. Southall, author of the work entitled "Epoch of the Mammoth."

Deep-Sea Soundings. A Lecture by Lieutenant-Commander T. F. Jewell, U. S. N., Claremont, N. H.: Manufacturing Company print. Pp. 63.

The first material improvement made in deep-sea sounding instruments was the employment, by Lieutenant Walsh, U. S. N., of a steel wire in place of a hempen cord; that was about thirty years ago. Since then sounding has received much attention from naval officers and scientific men, and so numerous are the devices contrived for the purpose of exploring the bottom of the sea, that the author of the above-named address finds it necessary, with a view to presenting a clear history of the subject within the ordinary limits of an evening lecture, to confine himself to the achievements, in this field, of our own countrymen. From a perusal of the address, it is seen that American inventive genius has played an important part in the improvement of sounding-instruments.

PUBLICATIONS RECEIVED.

Parks and Gardens of Paris considered in Relation to the Wants of other Cities and of Public and Private Gardens. By W. Robinson, F. L. S. With numerous Illustrations. New York: Macmillan. Pp. 572. $7.50.

American Ornithology; or, The Natural History of the Birds of the United States. By Alexander Wilson and Charles Lucian Bonaparte. Illustrated with Plates engraved from Drawings from Nature. Philadelphia: Porter & Coates. Three volumes in one. Pp. 1178. $7.50.

Life of George Combe, Author of "The Constitution of Man." By C. Gibbon. London: Macmillan. 2 vols. Pp. 335 and 404. $8.

A Candid Examination of Theism. By Physicus. Boston: Houghton, Osgood & Co. Pp. 215. $2.50.

What is the Bible? By J. T. Sunderland. New York: Putnams. Pp. 189. $1.

Goethe: Faust—Erster Theil. Edited, with an Introduction and Notes, by J. M. Hart. Same publishers. Pp. 257. $1.25.

The Ethics of Spiritualism. By H. Tuttle. Pp. 155. 60 cts.

Ferns in their Homes and Ours. By J. Robinson. With Plates and Woodcuts. Salem: S. E. Cassino. Pp. 194. $1.50.

Evolution evolved. A Part of "The Problems of Human Life here and hereafter." By Wilford. New York: Hall & Co. Pp. 132. 50 cts.

Central Ohio Scientific Association. Urbana: Saxton & Brand print. Vol. I., Part 1. Pp. 100, with Plates.

Geography of Kentucky. By W. J. Davis. New York: Van Antwerp, Bragg & Co. Pp. 16, with Map and Woodcuts.

American Journal of Mathematics, Pure and Applied. New York: Sold by Van Nostrand. Vol. I., No. 3.

Eleventh Annual Report of the Trustees of

the Peabody Museum of American Archæology and Ethnology. Cambridge: Printed by order of the Trustees. Vol. II., No. 2. Pp. 280, with Illustrations.

Observations and Orbits of the Satellites of Mars, with Data for Ephemerides in 1879. By A. Hall. Washington: Government Printing-Office. Pp. 46.

Origin of Comets. By H. A. Newton. From *American Journal of Science*. Pp. 15.

Selenide of Bismuth. By J. W. Mallet. From *American Journal of Science*. Pp. 3. Production of Magnesian Nitride by Smothered Combustion of Magnesium in Air. Same author. Pp. 2.

Palæolithic Implements from the Glacial Drift in the Valley of the Delaware, near Trenton, New Jersey. By Dr. C. C. Abbott. From the "Report of the Peabody Museum." Salem: Printed at the Salem Press. Pp. 32.

Fermented Liquors. By Dr. A. J. Howe. Pp. 8.

Manual Education. By Prof. C. M. Woodward. St. Louis: G. I. Jones & Co. Pp. 31.

Report on Cold-rolled Iron and Steel. By R. H. Thurston. Pittsburg: Printed by Stevenson, Foster & Co. Pp. 109, with Plates.

Rate of Earthquake-Wave Transit. By R. Mallet. From *Philosophical Magazine*. Pp. 4.

A Mass of Meteoric Iron from Augusta County, Virginia. By J. W. Mallet. From *American Journal of Science*. Pp. 2.

Contributions to Natural History. By R. E. C. Stearnes. San Francisco. Pp. 6.

Electric Constitution of our Solar System. By J. Ennis. From "Proceedings of the Academy of Natural Sciences of Philadelphia." Pp. 17.

Some Seleniocyanates; Electric Estimation of Mercury: Some Specific Gravity Determinations. By F. W. Clarke. From *American Journal of Science*. Pp. 6.

Illinois State Laboratory. Circular of Information. Springfield: *State Register* print. Pp. 14.

POPULAR MISCELLANY.

Effects of Oxygen inhaled at Different Temperatures.—Dr. B. W. Richardson finds great diversity in the action of oxygen on the animal economy according to the temperature of the gas when inhaled. Carefully-purified oxygen may be inhaled at 55° Fah. without a consciousness of the difference between it and common air. But before long, even though the products of the combustion of the animal be all removed, there is a gradual decline of the animal's temperature, followed by a tendency to sleep. At last death occurs in deep sleep. At a temperature lower than 55°, the narcotism produced by the oxygen is very much quickened. At 32°, in a chamber of oxygen, Dr. Richardson has seen deep coma induced in mice, pigeons, and Guinea-pigs, within thirty-five minutes of the commencement of the inhalation, death from coma supervening within an hour. In a raised temperature (75°), the inhalation of oxygen may be sustained without coma, indeed without injury, for a considerable time. To determine this point, Dr. Richardson constructed a small room that could be steadily ventilated with pure oxygen gas. In this room he kept adult warm-blooded animals on one occasion for three weeks without being able to observe any variation from the natural life that could be considered detrimental. In this instance the blood was always of the same color in the veins as in the arteries, viz., of a rich bright arterial crimson. Another experiment showed that, like heat, electricity modifies oxygen as a supporter of animal life. Dr. Richardson placed three full-grown mice in jars, each containing a hundred cubic inches of pure oxygen gas. One of these animals was placed now in a temperature of 45° Fah.; another in a temperature of 75°; the third was placed in the same temperature as the first, but with this difference, that into the jar containing the animal there was introduced a pointed copper wire connected with the positive conductor of a frictional electric machine. When the machine was set in motion, a brush was produced at the point of the copper wire. Every five minutes this electric brush was excited within the jar. The animal in the first jar would sleep to death in two or three hours; those in the second lived for many hours; in the third the animal fell into a narcotized condition, but nevertheless continued to live in sleep so long as the electrical excitation continued. Under these conditions it lived for seventeen hours in gentle sleep, and on being then set free showed no sign of injury, and lived on as before the experiment.

A Torpedo Transport.—A war-vessel of an entirely novel character, the Hecla, lately arrived at Portsmouth, England, from Belfast, where she was constructed for the British naval authorities. The Hecla is designed to carry fast torpedo launches and to follow in the wake of a fleet as a depot, ready to dispatch her flotilla of small craft for its protection when needed. She is an iron vessel, 390 feet in length, and is fitted to carry six sixty-four-pounder rifled guns.

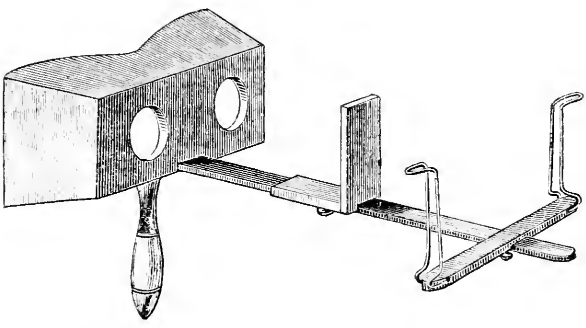
On each side is a broadside port through which Whitehead torpedoes may be launched. The after-part below is fitted up as a torpedo workshop. The hull is divided into a number of water-tight compartments, not connected, as is the usual mode, with water-tight doors, entrance being gained from the upper and main decks. The element of danger resulting from leaving the connections open in certain eventualities is thus obviated, though it is calculated that the filling of one or two of the compartments with water would not materially affect the behavior of the ship. She is to carry six second-class torpedo-boats. Four of these boats will be amidships, the chocks on which they rest running on a tramway. She will also carry a 42-feet steam launch and a 37-feet steam pinnace. The Hecla will be provided with booms and nets to protect her from an enemy's torpedoes—the booms, when not in use, lying fore and aft against the side of the ship.

Women and the Study of Science.—The medical profession in England appears to be seriously alarmed at the prospect of an invasion of its ranks by womankind. Scientific workers need have no such fears of their peculiar field being occupied by the gentler sex, if the "Cambridge Higher Local Examinations," lately held, are any index of the disposition of women-students in England toward scientific studies: only about thirty out of five hundred female students, we are informed by *Nature*, took the science subjects; twenty-one took botany, one failed, and three obtained distinction; twenty-six geology and physical geography, of whom two failed, and seven were distinguished; seven geology, one failed, three distinguished; nine chemistry, three failed, none distinguished. Ten of the science candidates sat at Cambridge, and among them they gained ten out of fourteen of the distinctions given. Miss E. M. Clarke, of Cambridge, was distinguished in geology, zoölogy, and botany, and passed in chemistry. Mathematics got only twenty-three candidates, of whom four failed; only two, however, were placed in the first class (being Cambridge students), and two in the second. We are glad to learn that two new subjects are to be set in the science group next year, namely, physics and physiology, the latter so much needed in all girls' schools. Also, students will be allowed to take this group without having to pass Group A (literature and history) first, although it will be required for a full certificate.

Sir Wyville Thomson on Deep-Sea Soundings.—Sir Wyville Thomson, as President of the Geographical Section of the British Association, delivered an address, at the Dublin meeting of that body, on the results of recent deep-sea sounding. He dwelt particularly on the facts of ocean circulation as developed by the Challenger Expedition. All recent observations, he said, have shown that the vast expanse of water which has its centre in the southern hemisphere is the one great ocean of the world, and the Atlantic with the Arctic Sea, and the North Pacific, are merely its northward-extending gulfs: any physical phenomena affecting obviously one portion of its area must be regarded as one of an interdependent system of phenomena affecting the ocean as a whole. Shallow as the stratum of water forming the ocean is—a mere film in proportion to the radius of the earth—it is very definitely split up into two layers, which, so far as all questions regarding ocean-movements are concerned, are under very different conditions. At a depth varying in different parts of the world, but averaging perhaps five hundred fathoms, there exists a layer of water at a temperature of 40° Fahr., which may be regarded as a sort of neutral band separating the two layers. Above this band the temperature varies greatly over different areas, the isothermobathic lines being sometimes tolerably equally distributed, and at other times crowding together toward the surface, while beneath it the temperature almost universally sinks very slowly and with increasing slowness to a minimum at the bottom. With some reservation it may be affirmed that the trade-winds and their modifications and counter-currents are the cause of all movements in the stratum of the ocean above the neutral layer. All the vast mass of water, often upward of two thousand fathoms in thickness below the neutral band, is moving slowly to the northward; in fact, the depths of the Atlantic, the Pacific, and the Indian Ocean, are occupied by

tongues of the Antarctic Sea, preserving in the main its characteristic temperature. The explanation of this seems simple. For some cause or other as yet not fully understood, evaporation is greatly in excess of precipitation in the northern portion of the land-hemisphere, while in the water-hemisphere, and particularly in its southern portion, the reverse is the case: thus one part of the general circulation of the ocean is carried on through the atmosphere, the water being raised in vapor in the northern hemisphere, hurried by upper-wind currents to the zone of low barometric pressure in the south, where it is precipitated in the form of snow or rain, and welling thence northward in the deepest channels, on account of the high specific gravity dependent on its low temperature, it supplies the place of the water which has been removed.

A New Form of Stereoscope.—It is known to many people that, by placing the axes of the eyes parallel, it is possible so to see stereoscopic pictures without any instrument as if we were looking at them through stereoscopic lenses. To do this, we may make a small hole in the centre of each picture, and hold the paper in such a position that each eye looks through the hole at a distant object. But with ordinary stereoscopic pictures this object needs to be very far off, so that this contrivance is not a very convenient one; nor is it desirable to make a hole in the centre of every picture we wish to see stereoscopically with our naked eyes. Another method is to make one familiar with the muscular sensibilities of the eyes according as their axes converge or diverge, and to make him acquire such control of his eyes that, without looking at any distant object, he will be able to place the axes of the eyes parallel. Though either of the above methods would answer for experimental purposes, neither would serve as a substitute for the ordinary stereoscope; for if one requires such an inconvenient arrangement, the other requires too much trouble in explaining. But I thought that, perhaps by some happy, simple contrivance, we could see stereoscopic pictures unaided by any lenses, yet *without any conscious straining of our eyes;* and after repeated experiments I found out that, if corresponding parts of two pictures were apart from one another only one inch and a half or so, and if by means of a partition the two pictures were so separated from one another that the right eye will see only the right picture and the left eye the left picture, the two pictures will combine just as easily as with an ordinary stereoscope.



The following is my explanation why two pictures combine so easily when corresponding parts of the two are apart only one inch and a half or so, while to make ordinary stereoscopic pictures combine requires so great effort:

To combine ordinary stereoscopic pictures unaided by any lenses, the axes of the eyes must be placed parallel; but, since it is not an habitual position of our eyes to have their axes parallel, this can only be accomplished by a great effort. But, if to place the axes parallel requires such an effort, to make them too convergent requires equally great effort. Thus to see a single image of a finger put on the tip of our nose is very difficult, and to see a single image of the tip of the nose itself is almost an im-

possibility. With the habitual positions of our eyes, the axes are neither parallel nor too convergent, and we see dimly two images of our nose and objects too near our eyes. Now, when corresponding parts of two stereoscopic pictures are apart from one another only one inch and a half or so, and are distant from our eyes one foot or so, to combine the two pictures our eyes are only required to take one of their habitual positions; that is, the axes of the eyes *need only to be so placed as if we were looking at an object distant from our eyes two feet or so:* hence the effort required is very trifling, even when unaided by any instrument. But when the two pictures are so separated by a partition that the right eye can see only the right picture and the left eye the left picture, the combination of the two will take place as easily as with an ordinary stereoscope. This is, I think, chiefly owing to the fact that *as long as the two pictures are seen separate, the picture seen by each eye is covered by a dim image of the partition seen by the other eye, and it is only when they combine that we have a clear and distinct view of the pictures.*—M. Toyama.

Natural Selection.—An interesting case of the operation of the law of natural selection and the survival of the fittest is recounted in the *American Naturalist*, by S. F. Clarke. Having obtained a number of the gelatinous egg-masses of one of our native salamanders, he placed them in large glass jars, where they developed rapidly. After their gills and balancers had developed, they emerged from the eggs and began their active life in the water. A difficulty now appeared—the author could not discover the proper kind of food. Upon watching the animals closely, however, he soon found that they were eating off one another's gills. Closer examination showed that among the many were a few individuals which, although they came from the same parents and were subjected to the same conditions while in the egg, were yet gifted with greater vigor than most of their fellows. These few stronger ones ate off the gills of many of the weaker, and at the same time were enabled to protect their own gills from mutilation. These favorable conditions, the large supply of food, and the better aëration of the blood, soon began to show their influence upon the growth of the favored individuals. Within a week or ten days from the time of emergence from the egg, these favored few were fifty per cent. larger than their weaker comrades who were born upon the same day. Their mouths had by this time so increased in size that, no longer satisfied with nibbling off the gills of their brethren, they now began to swallow them bodily. Soon they were ten or twelve times as great in length and bulk as their victims.

Carnivorous Caterpillars.—A striking peculiarity of the caterpillars of Patagonian *Lepidoptera*, namely, their cannibalism, is noticed by Prof. Carl Berg. All caterpillars in Patagonia, of whatever family or group, prey upon their own kind. He kept them in captivity, and found that, even with an abundance of food-plants at hand, they preferred to devour one another, "hair and hide;" they even tear open the cocoons and prey on the chrysalids. One was observed to devour in twenty-four hours six or seven individuals of its own species. This peculiarity of Patagonian caterpillars is thus explained by the author: During the summer there are extreme heat and drought in Patagonia, and these causes, together with the prevailing dry winds, parch the vegetation, scanty at best. The caterpillars are in consequence greatly straitened for food, and the struggle for life has led them to seek some other means of subsistence. Hence their cannibalism, which, being transmitted by heredity from generation to generation, becomes a second nature, and the practices to which they were at first driven by want they now perpetuate through habit.

A Battle-Royal among Ants.—F. E. Colenso, of Maritzburg, Natal, in a letter to *Nature*, gives an animated description of a fierce battle between ants, which he found engaged in mortal combat on his garden-wall. Among the ants was a considerable number of larger individuals, "the soldier-ants" of the same species, and the whole ant community seemed to be bent on destroying them. A group of little ones would fasten on to a big one, the latter in the mean time making desperate efforts to

free itself. Or a big one would bite several little ones in two, but after a while the little ones would have severed all the legs of the big one, and finally would get on his back and cut him in two. One combat was especially noticeable, and is described as follows by the author: "A big ant walked along till it met another big one, and the two shook antennæ. Just then a little one seized hold of a hind-leg of one of these big ones. Neither took any notice, but continued a rapid conversation. Suddenly other small ones came up, when the big one whose leg was grabbed turned furiously on the little one and seized him by the middle. This could not be done until the big one had doubled himself up; as soon as he had hold of his small antagonist, he lifted him in the air and snipped him in two. Meanwhile all the big one's legs had been seized by little ones, and the party seemed to turn over and over, little bits tumbling down off the wall, now a leg, now half an ant, till the big one was vanquished. The way in which the big ant turned on the little one was singularly indicative of rage. The determined manner in which he laid hold of the little one was quite human."

How the Silk-worm Moth escapes from its Cocoon.—Having heard a rustling, cutting, and tearing noise issuing from a cocoon of *Actias luna*, the large green swallow-tailed silk-worm moth, Prof. A. S. Packard supposed that the moth must be engaged in cutting its way out of the cocoon. And as the mode of escape is a subject of dispute among entomologists, Prof. Packard determined to observe the moth at its work. A sharp black point was seen moving to and fro, and then another, until both points had cut a rough, irregular slit, through which the shoulders of the moth could be seen vigorously moving from side to side. The slit was made in one or two minutes, and the moth worked its way at once out of the opening. Afterward, in examining two dry specimens of the same moth, this black point or spine was seen at the base of each fore-wing; Mr. Packard calls it *sector coconis*—the cocoon-cutter. A number of other members of the sub-family *Attaci* having been examined, the sector was found in them all. In the common silk-worm (*Bombyx mori*), the spines are not well marked, and they are quite different from those in the *Attaci*, and consist of three sharp points, being acute angles of the pieces at the base of the wing.

The Musk-Bison.—*Ovibos moschatus* (musk sheep-ox, i. e., the musk-ox), as its systematic name indicates, possesses external characters common to the sheep and the ox, and hence it has been regarded as forming the connecting link between these two species. But, as a writer in *Land and Water* points out, the name given to the animal by Pennant, namely, musk-bison, more correctly defines its zoölogical position. Of this interesting animal, the writer just mentioned says that it measures only about five and a half feet from the tip of the nose to the root of the tail. Its average weight is usually estimated by travelers at 700 pounds, but the author thinks that 300 pounds would probably be nearer the weight of the largest individuals. The outer hair, or fleece, is long and thick, brown or black in color, frequently decidedly grizzled, hanging far below the middle of the leg. Underneath this shaggy coat, and covering all parts of the animal, though much the heaviest upon the neck and shoulders, is found a fine soft wool of exquisite texture, of a bluish-drab or cinereous hue, capable of being used in the arts and of forming the most beautiful fabrics. It is this close under-fur which enables its wearer to withstand the bitter storms and piercing cold of arctic winters, even beyond the seventieth parallel of latitude. The head is large, ending in a rather short muzzle, though remarkably broad nose, the nostrils being bordered and separated by a naked narrow space. The forehead is convex, and both sexes are provided with horns, which are of extreme size, and not unlike those of the male of the Rocky Mountain sheep in curve and general appearance, but lacking the transverse corrugations that characterize the latter. In the male, these appendages approach so closely together in the centre of the forehead as to appear to be joined at their bases, as they undoubtedly are in old age. Leaving the point of insertion, the horns are directed outward and laterally, falling down abruptly on either side of the face, curving slightly

forward through their middle third, and, opposite the angle of the mouth, turning sharply upward at the tip. In the female they are placed farther apart in the skull, measure much less in circumference at the point of insertion, and, though they likewise fall down and present the same curve as those of the bull, the points are not in the least inclined upward, but rather down, or in the same plane with the lips. They are powerful weapons, however, serving both sexes equally well either for offense or defense. They are very broad next to the skull, but taper swiftly toward the points, which are very sharp, and present a dull whitish-yellow color, rough at the basal extremity, but smooth and shining beyond, and black at the tips. The average proportions of a pair of horns are two and a half feet across from tip to tip, and each two feet in length, measured from the median line of the forehead, to which they are attached by a characteristic boss or protuberance. A pair frequently weighs upward of sixty pounds. The tail is very small, and completely hidden by the long hair of the voluminous fleece. The legs, too, are short and greatly concealed by the long hair of the shoulders and flank. The feet are four-toed, and armed with hoofs like all ruminants, the two anterior and largest being broad and inflexed, with sharp cutting edges, and the posterior or lateral ones, which are but slightly developed in most quadrupeds, are considerably prolonged, almost reaching to the ground; this, with the upward curve and great expansion, of which the front hoofs are capable, presents a structure which, by giving the animal a broader base to stand upon, prevents its sinking too deep into the snow, or when traversing boggy ground. Without this, the musk-ox would have been as ill-fitted to tramp over the yielding snow-fields of the north as the camel to perform long marches through the burning sands of tropical deserts without his broad, elastic sole-pad.

Sagacity of the Beaver.—A Mississippi correspondent of *Chambers's Journal* recounts several interesting instances of the sagacity of the beaver, and of the readiness with which that animal grows accustomed to the presence of man. At a place near this correspondent's residence a railroad crosses some wet, springy ground, where there used to be several beaver-dams. The line of embankment supplied the place of these dams, and the beavers, taking the good the gods provided, worked no more on their own dams, but enjoyed the pond of four or five acres which the embankment had made for them. A year or two since, the railway-workmen undertook to put a culvert through the embankment and drain the pond, which, after running freely for a few days, and nearly emptying the pond, suddenly stopped one night: the flow had been arrested by the beavers. The men opened it again, but once more it was stopped up. This went on for some time. As the men passed that way they would open the entrance to the culvert, and at night the beavers would shut it up. At length, finding that closing at the entrance, where their work could so easily be broken down, did no good, the beavers moved their dam to the middle of the culvert, which was some forty feet long, out of the reach of the poles used to poke it down. Here was a community of beavers working with express-trains thundering over their heads!

A Useful Snake.—In "Notes on the Natural History of Fort Macon, North Carolina," contributed to the "Proceedings" of the Academy of Natural Sciences of Philadelphia, Drs. Coues and Yarrow describe the king-snake (*Ophibolus getulus*), which is said by the residents frequently to destroy both rattlesnakes and moccasins, eating its victims after the conflict is over. For this reason the king-snake is in great esteem, and is carefully protected. The fight which takes place between the *ophibolus* and the rattlesnake has often been witnessed, and is described as follows: So soon as the rattlesnake sees his enemy, he endeavors to escape if possible, and, failing in this, he instantly throws his body into coils. The king-snake approaches swiftly, and moves around the rattlesnake in a circle, gradually drawing nearer and nearer, the rattlesnake following his motions with his head. The circular movement of his antagonist appears finally to disconcert him, for after a time it is noticed that his movements are less energetic, and at length, in an unguarded mo-

ment, *ophibolus* throws himself suddenly upon him and chokes him to death, pulls his body apart, and devours him. In captivity the king-snake is very gentle, and it requires very severe provocation to induce it to bite. Several specimens which were kept in a large box could not be induced to eat either mice, frogs, or toads; but as several fine specimens of *Ophiosaurus ventralis*, kept in the same box, quickly disappeared, it was easy to account for the apparent want of appetite.

The "Uses" of Pain.—The question is often asked, "What is the use of pain? It is scarcely conceivable that the infliction has no object." There are obviously two aspects of this question: in one Science has an immediate interest; with the other it has a secondary but not unimportant concern. The first is essentially physical. What useful purpose does pain subserve in the animal economy? The answer is thrust upon us by daily observation and experience. There are two sentinels posted, so to say, about the organism to protect it alike from the assaults of enemies without and exacting friends within. The first of these guardians is the sense of *fatigue*. When this speaks, there is need of rest for repair. If the monitor be unheeded, exhaustion may supervene; or, before that point of injury is reached, the second guardian will perhaps interpose for the vital protection—namely, *pain*. The sense of pain, however, is more directly significant of injury to structure, active or threatened, than an excessive strain on function, although in the case of the vital organs pain occurs whenever the pressure is great. Speaking generally, it may be set down as an axiom that, whatever collateral uses pain may subserve, its chief and most obvious service to humanity is as a deterrent and warning sensation to ward off danger. It is worthy of note, though sufficiently familiar to medical observers, that the absence of this subjective symptom in cases of severe injury is too often indicative of an injury beyond repair. The extinction of pain is not the highest, although it may be a generous, impulse. If there were no guardian sensibility of this nature, it would be impossible to live long in the world without self-inflicting the most formidable injuries. That pain, in the second place, has an educational value, as regards the mind and temper, no one can doubt. Some forms of pain would seem to be chiefly intended for this purpose; but even in this view pain has a practical interest, because the higher development of the mind which controls the body, and of which the brain is the formative organ, is a process of physico-mental interest governed by natural laws of which Science is perfectly competent to take cognizance. The subject as a whole is one with which the physician and physiologist have much concern.—*Lancet.*

Discovery of a New Salt-Deposit in Central New York.—Mr. James McFarlan announces the discovery of a bed of rock-salt in the Onondaga salt-group at a locality thirty-seven miles south of Rochester. The boring which resulted in this discovery passed first through 660 feet of shales, then 110 feet of hard rock—sandstone or limestone—then 80 feet of hard limestone, when salt-water was found. Below this was 380 feet of limestone and shale belonging in part to the limestones and shales of the upper part of the Onondaga salt-group; next, 1,240 feet down, soft shales, 20 or 30 feet thick, were passed through; and, finally, the bed of rock-salt was struck at the depth of 1,279 feet. It had a thickness of 70 feet, of which 40 or 50 was pure salt. The boring was continued to the depth of 1,530 feet, down to the Niagara limestone, which was met at 1,562 feet. Borings are to be made on the south side of the Syracuse Valley, in the expectation of striking the same bed, which there would be found, if at all, at the depth of only a few hundred feet.

Distribution of Spiders.—In classifying the collection of spiders in the museum of the Academy of Natural Sciences of Philadelphia, the Rev. H. C. McCook discovered specimens of *Sarotes venatorius*, a large spider coming from various localities—from Santa Cruz (Virgin Islands) to Cuba, to Florida; across Central America, Yucatan, and Mexico; across the Pacific Ocean by way of the Sandwich Islands, Japan, and the Loo-Choo Islands, and thence across the continents of Asia and Africa to Li-

beria. He noticed that this line of distribution lies within the belt of the north trade-winds, and conjectured the existence of some connection between the two facts. Probability was given to the conjecture by the migratory habits of this spider in the early stages of its growth. The young spider emits from the spinnerets fine threads in sufficient bulk to overcome the specific gravity of the body, and it is borne through the air like a balloon. We some time ago gave an account of Mr. McCook's observations on ballooning spiders. Having found this spider in localities lying in the track of the northern trades, Mr. McCook made an investigation to determine whether the species is distributed along the entire track, and also whether it is to be found in the track of the southern trades. The result is exhibited by the author in a map which shows the existence of *Sarotes venatorius* in both belts of the trades, from the east coast of America, across this continent, the Pacific, and the whole Eastern Continent, to the west coast of Africa, thus girdling the globe, with the exception of 54° of longitude corresponding to the width of the Atlantic Ocean. The inference is that the distribution of this spider has been accomplished by means of the trade-winds.

The Growth of Mushrooms.—It is generally supposed that mushrooms grow only in the night, but those who have watched them have observed that their growth is nearly equal day and night. A correspondent writes that not long since a flower-pot was filled with dirt from the street, a plant was placed therein and it grew rapidly. In ten days a small mushroom made its appearance, but in a few hours it toppled over and perished. On the following day a larger one of different species was discovered peeping through the soil, and in the morning it was just above the surface. Before nine o'clock at night it attained its full height, nearly four inches, although it was in the sun several hours, and gradually expanded its acorn-head into a hollow cone which united with the hollow stem at the interior of the apex. Its inner surface was lined and evenly shirred with a black, velvety substance which made a fine contrast with the milk-white, cobweb-like substance of the outer surface. During the day and night the head was transformed into an umbrella-like cap, which collapsed and died on the fourth day. Others of different species made their appearance at different times, showing that the streets of a city as well as the soil of the country are filled with spores of these seedless and flowerless plants ready to show themselves whenever the conditions of germination are favorable. They do not propagate by seeds—they have none—they propagate by spores, microscopically small, which are driven hither and thither by winds and lodged in various places, and when they receive the requisite amount of moisture and heat they germinate and grow to perfection, whether it be day or night.

Mercurial Deposit on Animal Teeth.—On the teeth of a sheep said to have been poisoned by the herbage growing in the neighborhood of a certain silver-mine in Mexico, Mr. E. Goldsmith, of the Academy of Natural Sciences of Philadelphia, noticed a peculiar deposit of tartar, which was supposed to consist of silver amalgam. Upon examination this tartar was found to constitute a thin scale covering the teeth to the depth of about 0.2 millimetre. Viewed under a lens of moderate power, the deposit seemed to have been built up gradually from within. Its lustre was truly metallic. Heated on platinum-foil it became black, showing the presence of organic matter. Heated in a tube closed on one end, at first a gray cloud arose, then water and an oily matter deposited themselves on the upper or cooler end of the tube; lower down near the now carbonized test a metallic layer was recognized with the aid of the lens. The powdered substance being mixed with carbonate of soda, and treated in the same way, the result did not differ. If melted on coal with the addition of carbonate of soda, there was obtained a white enamel, but no metal whatever. In nitric acid the tartar was soluble as long as the solution was concentrated; if diluted with water, a turbidity, caused by the separation of an organic matter, was formed. This organic matter was soluble in caustic ammonia, and from this ammoniacal solution it was again precipitable by nitric acid; the precipitate was flocculent, it carbonized when heated, and left no resi-

due if the heating was prolonged for a sufficient time. The remaining solution from which this organic substance had been separated gave no reaction with hydrochloric acid, the absence of silver being thereby proved. A stream of sulphureted hydrogen gave a precipitation in which a very little quantity of sulphuret of mercury was discerned. Very strong reactions of phosphoric acid and lime were observed in the nitric-acid solution with the ordinary reagents. This singular tartar is consequently not silver amalgam, but the same material of which teeth are generally made, modified, however, by the influence of a small quantity of mercury. That metallic mercury is easily absorbed by the animal economy is well known; it seems, however, not to have been noticed on the outside of the teeth before.

The Grave-Digger Beetle.—In order to test the strength of the grave-digger beetle (*Necrophorus Germanicus*) Mr. Gleditch, an entomologist, half filled a glass vessel with earth, into which he put four of the beetles with a dead linnet. The grave-diggers immediately began to excavate beneath the dead body of the linnet, shoveling away the earth on each side. After laboring for nearly two hours, one of the beetles was driven away and not allowed to work again. The others continued their labor, until one by one they ceased, leaving only one beetle at work. Five hours, more hard work was given by the remaining beetle, who at last sank exhausted on the earth and rested from his task, and finally, suddenly rousing himself, stiffened his collar, and by an extraordinary effort of strength lifted up the bird and arranged it within the spacious grave. In three days the grave was finished, and the bird safely deposited within its narrow limits. During a space of fifty days, these busy workers interred the bodies of four frogs, three small birds, two grasshoppers, and one mole. This singular occupation, which continues from the middle of April until the end of October, proceeds from an instinctive desire for the preservation of their offspring. Eggs deposited by the parent in the substances which they inter, when hatched, produce larvæ, which, feeding on the carrion which surrounds them, grow to an inch in length. These in their turn change into yellow chrysalids, and lastly into beetles; and the latter, when emerged from the earth, begin to dig graves and inter dead animals for the benefit of another generation.

A New Mineral White.—For many years chemists have been trying to find some mineral white which might be substituted for the costly and poisonous white-lead. One of the substitutes proposed was zinc-white —oxide of zinc—but the "body" of zinc-white will not bear comparison with that of white-lead. Oxide of antimony, and the silicates of zinc, magnesia, and lime, were successively tried, but none of these substances proved to be an adequate substitute. Mr. T. Griffiths, of Liverpool, has obtained a mineral white the basis of which is sulphide of zinc, and which Dr. Phipson pronounces to be "in every respect superior to carbonate of lead itself," i. e., white-lead. It is obtained by precipitating either chloride or sulphate of zinc by means of a soluble sulphide—sodium, barium, or calcium sulphide —and precautions are taken lest any iron that may be present in small quantity should be precipitated with the white sulphide of zinc. The precipitate, being collected and dried, is transferred to a furnace, there calcined for some time at a cherry-red heat, and carefully stirred so as to bring all parts of it successively in contact with the air. It is then raked out while quite hot, into vats of cold water, where it is levigated, and afterward collected and dried. The result is a very fine white pigment; its covering power when mixed with oil is about 25 per cent. higher than that of carbonate of lead. Phipson's analysis of the new product shows it to be an oxysulphate of zinc. This white is not darkened by sulphureted hydrogen, and its manufacture is perfectly innocuous.

A Substitute for Gutta-Percha.—We take from an English journal the following account of a substance called *balata*, the milky sap of the bully-tree, which grows in the region of the Amazon and the Orinoco: Balata, we are informed, possesses many of the characteristics of India-rubber and gutta-percha; indeed, it so closely resembles

the latter substance in its general properties, that much of it is shipped yearly from Guiana and sold for that article, although in some respects it is greatly superior to gutta-percha. Like gutta-percha and India-rubber, this gum is obtained by making an incision in the bark of the tree, and allowing the sap to ooze out and either coagulate in a lump or flow slowly over a clay form so as to produce a "bottle" or any other pattern that may be desired. Balata is tasteless, gives out an agreeable odor on being warmed, is tough and leathery, is remarkably flexible, and far more elastic than gutta-percha. It can be softened and joined piece to piece indefinitely, at a temperature of about 120° Fahr., but requires a heat of 270° before it melts. It is completely soluble in benzol and bisulphide of carbon when cold. Turpentine dissolves it with the application of heat, while it is only partially soluble in anhydrous alcohol and ether. It becomes strongly electrified by friction, and is a better isolator of heat and electricity than gutta-percha. Caustic alkalies and concentrated hydrochloric acid do not attack it, but concentrated sulphuric and nitric acids do. A sort of artificial India-rubber, called "kerite," invented by A. G. Day, of this city, has recently been brought to notice. It is prepared in the following way: About twenty-seven pounds of cotton-seed oil and thirty pounds of coal-tar are mixed together in a boiler, with sufficient heat and for a sufficient length of time to cause them to unite thoroughly. The temperature should be about 300° Fahr., and the time is from three to five hours. The mixture is then cooled to from 200° to 240° Fahr., and then linseed-oil (twenty-seven pounds) is added. When the latter has been thoroughly mixed with the other ingredients, twelve to sixteen pounds of sulphur is added gradually, the temperature meantime being steadily raised to about 275° or 300° Fahr. The heating is continued till the mass is vulcanized. When the vulcanization is complete, the compound is finished, and it may then be poured into moulds or pans and allowed to cool for use. The inventor has lately made some considerable improvements in his process of preparing ozokerite, but it would take too much space to detail them here.

NOTES.

The American Association will next year hold its meetings at Saratoga, beginning on the last Wednesday of August. Prof. G. F. Barker, of Philadelphia, is the president.

Died, September 6th, at Brussels, Ernest Quetelet, of the Brussels Royal Observatory, aged about fifty-three years. Deceased was the son of the late Prof. Adolphe Quetelet, the eminent statistician, who was the founder of the Brussels Observatory, and its director till his death in 1874.

All the pterosaurian fossils hitherto discovered in the United States are from the Cretaceous. But in the *American Journal of Science* for September, Prof. O. C. Marsh describes a fossil specimen from the Upper Jurassic of Wyoming which proves the existence of that class of saurians in the formation just named. The specimen, which is in good preservation, is the distal portion of the right wing metacarpal, and indicates a small pterodactyl, having a spread of wings of four or five feet.

A very ingenious machine, invented by James H. Williams, was exhibited this fall at a Mechanics' Fair in Boston, viz., a machine capable of indicating, six to eight times per minute, the superficial area of surfaces, however irregular, not exceeding twenty-five square feet. The machine can, for instance, compute in less than ten seconds the square contents of a circle without reference to mathematical rules. It is certain to find practical application in many departments of trade. It is specially of use to leather dealers and manufacturers for measuring exactly the superficial area of hides and skins.

Gustav Wallis, the botanist, died at Cuenca, Bolivia, June 20th, aged forty-eight years. He first visited South America as a botanical collector in 1860, gathering new and useful species of plants, and during the ensuing eight years traversed Brazil, Peru, Ecuador, Bolivia, Colombia, Panama, and Costa Rica. He next visited the Philippine Islands, but in 1871 he again went to South America, never to return. He died in a hospital, in poverty, "worn out in the cause of science," says *Nature*. He introduced into European horticulture no less than 1,000 new varieties from across the Atlantic.

Good petroleum (kerosene), according to Prof. J. Lawrence Smith, should have the following characteristics: 1. The color should be white or light yellow, with a blue reflection; 2. The odor should be faint and not disagreeable; 3. The specific gravity, at 60° Fahr., ought not to be below 0.795 nor above 0.84; 4. When mixed with

an equal volume of sulphuric acid of the density of 1.53, the color ought not to become darker, but lighter. A petroleum that satisfies all these conditions, and possesses the proper flashing-point, may be regarded as pure and safe.

The Paris Academy of Sciences has elected Mr. Darwin a corresponding member of the Zoölogical Section, and Prof. Asa Gray a corresponding member of the Section of Botany.

We have received from Dr. G. E. Blackham, of Dunkirk, a report of what was done at the American Microscopical Congress, which met at Indianapolis in August. There were present about fifty microscopists from different parts of the United States, and Dr. R. H. Ward, of Troy, New York, was chosen president. The congress was in session for four days, August 14th, 15th, 16th, and 17th, and one of its results was the organization of a permanent association, "The American Society of Microscopists." A large number of papers were read, among which may be named the following: "On the Limits of Accuracy in Measurement with the Microscope," by Prof. W. A. Rogers; "A Standard Micrometer," by Prof. R. Hitchcock; "Progress of Microscopic Ruling," by Prof. J. E. Smith; and "Construction of Oculars," by W. H. Seaman. The society will meet next year at Buffalo.

Prof. Hughes entertains the hope, or rather thinks it possible, that we shall one day be able to "tap the brain of its thought" by means of the microphone! He holds that all thought is accompanied by an unconscious action of the articulating organs, and that therefore it may come to pass that by a highly-sensitive microphone the articulate vibrations of the head will be made audible. Of course, the theory that unconscious articulation always accompanies thought is purely hypothetical; but in these times it is best not to pronounce anything impossible unless it clearly implies a contradiction in terms—an absurdity.

Experiments made by Messrs. Corenwinder and Contamine show that the amount of sugar in beet-roots is in direct ratio to the superficial area of their leaves. They further show that in the leaves the sugar occurs mainly in the midrib, and that it there exists in the state of glucose mingled with a small quantity of crystallizable sugar. In the secondary veins and in the parenchyma the proportion of sugar is far less considerable.

The London *Academy* is authority for the statement that Mr. Grenville Murray's recent work, "Round about France," has been seized in France by the authorities.

Dr. Weyl points out in the *Chemische Industrie* the defects of the usual methods of determining the heat-value of fuels, and recommends, as preferable, decomposition of the fuel by dry distillation and analytical determination of the solid, liquid, and gaseous products of decomposition. The water, tar, and gas that are formed are measured and their heat of combustion ascertained with the aid of data that have been supplied by Favre and Silbermann and Deville. The final result will, of course, exceed the true combustion-value of the coal by the amount of heat equivalent to the work of decomposition into coke, tar, and gas. The decomposition of the coal should be done as quickly as possible, and at a high temperature.

The French journal *La Science pour Tous* reckons the annual importation of ivory into England at 650,000 kilogrammes, of which about one half is there employed in the arts, and the other half reëxported. The cutlery-works of Sheffield alone consume 200,000 kilogrammes per year. Tusks vary in weight from 450 grammes to 74 kilogrammes. To supply the ivory annually taken to England, 50,000 elephants must be killed. But though, perhaps, most of the tusks go to England, very many are exported directly to other countries and consumed at home.

A process for treating hop-stems so as to produce from them textile fibres is thus described in the *Polytechnic Journal:* First, the stems are boiled in water with soda or soap, then washed again, and once more boiled in dilute acetic acid. They are then washed and dried, and when properly combed can be worked like other textile materials. The fibres are said very closely to resemble those of flax, and to excel in elasticity, softness, and durability.

A writer in the London *Times* asserts that, by the practice of shoeing horses, we diminish the sureness of the animal's feet, and foster all kinds of splints and other diseases. He maintains that any horse, even one accustomed to shoes, would very soon go more easily in every way on our hardest roads, and with far less liability to slipping and disease, unshod, than he now does when shod with iron. All that is necessary is to "keep the edges of the hoof slightly rounded off with a rasp, to prevent the raveling-up of the edges."

Señor Moreno, employed by the Government of Buenos Ayres to explore Patagonia, has discovered a new volcano, that of Chalten, in the Patagonian Andes, in latitude 49° 8′ south, longitude 73° 10′ west. It is a magnificent peak, rising high above the surrounding mountains, and the natives report that it is almost always sending forth smoke and cinders.

AUGUST HEINRICH PETERMANN.

THE

POPULAR SCIENCE MONTHLY.

DECEMBER, 1878.

EDISON'S TELEPHONIC AND ACOUSTIC INVENTIONS.

By GEORGE B. PRESCOTT.

SOME of the discoveries and inventions of Mr. Edison, that were made during his researches which culminated in the invention of the carbon-telephone, have already been published. We now propose to present a more complete description of the important forms of telephone upon which he then experimented, and to describe his more recent acoustic inventions.

The carbon-telephone is only one of many contrivances for reproducing articulate speech at a distance through the aid of electricity, but, owing to its clear and truthful articulation, its simplicity of construction, and the far greater volume of sound which it creates, is probably destined to be the most extensively used. Other instruments of Mr. Edison's invention, however, are not far behind it, and may by improvement be made equally effective.

As a rule, Mr. Edison has succeeded better with those telephones which produce a variation in the resistance of the circuit than with those which depend for their action upon a variation of the electromotive force or static charge. An instrument very similar to the carbon-transmitting telephone is shown in Fig. 1, the essential difference being that the carbon is replaced by bibulous paper moistened with water. This semi-conductor, like the carbon, changes its resistance under the influence of varying pressure. The paper is kept moist by capillary action, a strip being used, one end of which dips into a reservoir of water.

In Fig. 2 is shown a form of the carbon-transmitting telephone, requiring no adjustment whatever. It operates well, notwithstanding the simplicity of its construction. A plate of metal rests on the bottom of a hollow vessel. On this is placed a block of prepared carbon, upon which a second and light plate is laid.

The weight of the upper plate affords an initial pressure which is varied by speaking into the mouth of the vessel.

The carbon-block may be replaced by a disk of cloth, the pores of which have been filled with pulverized black-lead. By this treatment the cloth becomes slightly conductive. The instrument thus modified is shown in Fig. 3.

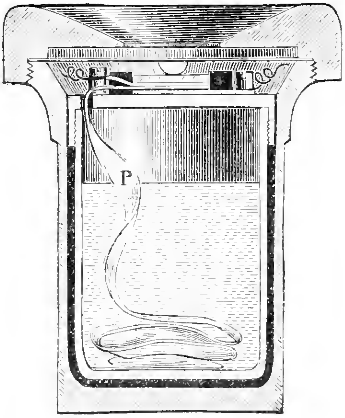


FIG. 1.

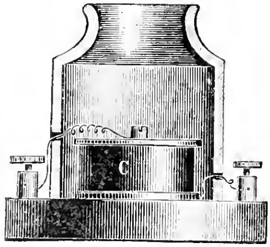


FIG. 2.

FIG. 3.

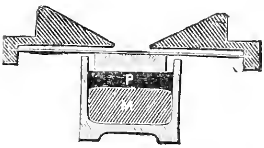


FIG. 4.

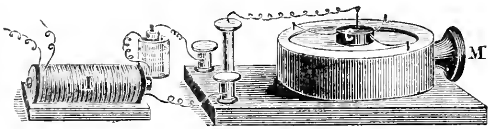


FIG. 5.

In Fig. 4 the pulverized plumbago, *P*, is floated upon mercury, *M*, and is compressed between the surface of the mercury and a metallic block fastened to the centre of the diaphragm.

Still another form of the Edison transmitter is shown in Fig. 5. The carbon, *C*, rests upon the diaphragm, which in this instrument is an horizontal plate forming the top of a vocalizing chamber, the mouth-piece being at the side.

Three fine cords attach the carbon to the framework of the diaphragm, and prevent it from being displaced when the diaphragm is vibrating. In appearance this instrument resembles the Reiss telephone, and in principle it would be much the same were it not that, in vibrating, the carbon never actually leaves the plate upon which it rests, but simply for an instant releases its pressure. It is evident that the resistance of the circuit depends upon the electric connection between the carbon and the diaphragm, and that this connection depends

upon the pressure of the carbon, which is constantly changing when the diaphragm is in vibration.

Another form, acting on much the same principle, is illustrated by Fig. 6. It is called the inertia-telephone, though it is hardly certain that its action is to be attributed solely to inertia. The carbon, *C*, is placed between two metallic plates, one of which is fastened to the diaphragm, and the other is held by a screw, bearing in a framework attached to the diaphragm by insulating supports.

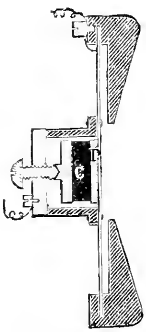


FIG. 6.

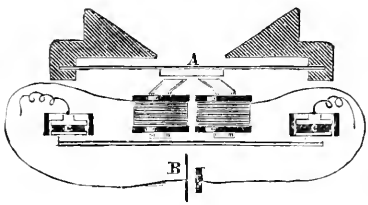


FIG. 8.

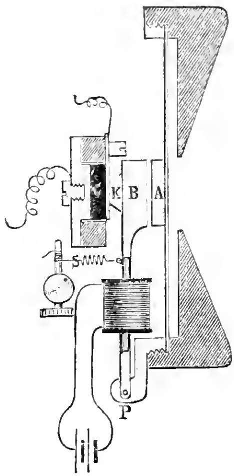


FIG. 7.

When vibrating, the whole system moves, instead of the plate *P* alone, as in the ordinary carbon-transmitter. Mr. Edison's explanation of its mode of action is, that the degree of pressure with which the carbon rests against the plates is varied during the vibration. Thus, after a movement toward the right, the diaphragm suddenly stops and the carbon presses, in virtue of its inertia, on the plate *P*.

An advantage which the magneto-telephone has over the carbon-telephone is that its diaphragm does not touch anything, and can therefore vibrate with perfect freedom. On the other hand, the diaphragm of the carbon-telephone presses with considerable force upon the carbon. In the form shown in Fig. 7 this difficulty is not encountered.

The diaphragm carries an armature, *A*, of soft iron, which confronts but does not touch the magnet *B*. *A* and *B* are opposite poles of the same magnet, being connected at *P* and polarized by a local circuit. The magnet *B* presses upon the carbon at *C*, the pressure

being regulated by the screw *S*. The attraction between *A* and *B* varies with the distance between them. When, in vibrating, *A* moves toward *B*, the attraction rapidly increases, and *B* lessens its pressure upon *C*. During a motion in the opposite direction the attraction diminishes, and *B*, drawn by the screw *S*, increases its pressure upon *C*.

A similar contrivance is illustrated in Fig. 8. The diaphragm carries an armature, *A*, which by its motion changes the potential of two electro-magnets. These changes in magnetism cause a bar situated in their magnetic field to reproduce the original vibrations. The ends of the bar are held by magnetic force against two pieces of carbon, *c* and *c*. These and the bar are included in the primary circuit of an induction-coil. The resistance of the circuit decreases when the bar is drawn up, and increases as the bar descends.

THE MICROPHONE.—The device of using several pieces of the semi-conductor instead of one was early tried by Mr. Edison. He found in general that the loudness of the sound was increased by thus multiplying the number of contact-surfaces, but also that the articulation was impaired. Instruments of this nature have since become known as microphones, though it is not probable that faint sounds were ever augmented through their agency. Fig. 9 shows one of the first forms of the microphone, invented by Mr. Edison, April 1, 1877. Four pieces

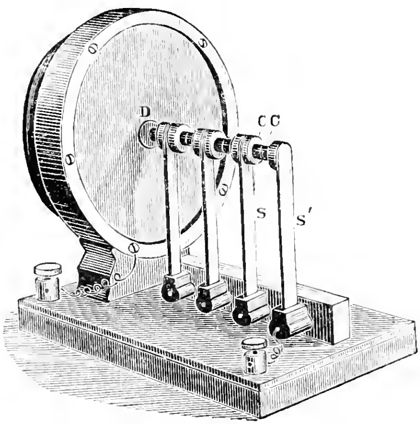


FIG. 9.

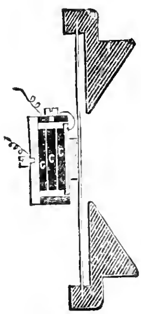


FIG. 10.

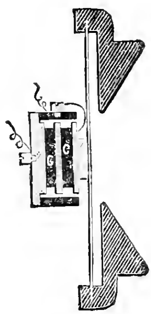


FIG. 11.

of charcoal are used, *C C*, etc., each supported by an upright spring, as at *S* and *S'*. The piece of charcoal nearest the diaphragm impinges upon a disk of carbon, which is fastened to the centre of the diaphragm. The primary wires of an induction-coil are attached to the diaphragm and the spring *S'*. The circuit is then completed through the semi-conductors. Other forms are shown in Figs. 10 and 11. The former has two carbons, separated by a plate of metal. The latter has three contiguous pieces of carbon.

Fig. 12 illustrates a microphone having ten plates of silk, a mixture of dextrine and lampblack having been previously worked into the pores.

In Fig. 13 fifty disks, *D*, of protoxide of iron, are shown inclosed in a glass tube.

A novel form of transmitter, used by Mr. Edison in his experiments, is shown in Fig. 14. The semi-conductor is a collection of small frag-

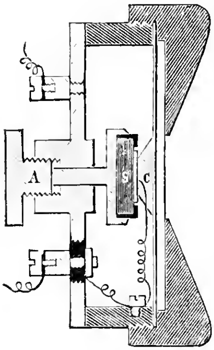


FIG. 12.

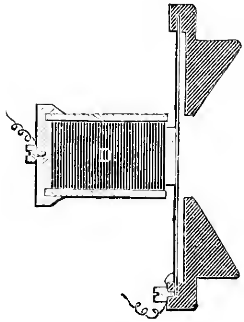


FIG. 13.

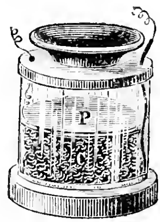


FIG. 14.

ments of cork, covered with plumbago. It can be used with or without a diaphragm.

The instrument shown in Fig. 15 acts both as a transmitter and receiver. The solid carbon of the transmitter is here replaced by silk fibres coated with graphite. Its action as a receiver is probably due to the attraction of parallel currents; the volume of the whole being contracted during the passage of a current through *F*.

In the accounts which have been published of experiments with the microphone, the statement has frequently been made that minute sounds are actually magnified by it, in the same sense that minute objects are magnified by the microscope. A little reflection will show, however, that there is no real analogy in the action of the two instruments. The sound that is heard in the receiving-instrument of the microphone, when a fly is walking across the board on which the transmitter is placed, is not the sound of the fly's footsteps, any more than the stroke of a powerful electric bell, or sounder, is the magnified sound of the operator's fingers tapping lightly, and it may be inaudibly, upon the key. This view of the subject readily explains why the microphone has failed to realize the expectations of many persons, who, upon its first exhibition, enthusiastically announced that by its aid we should be able to hear many sounds in Nature which had hitherto remained wholly inaudible.

SHORT-CIRCUITING TELEPHONES.—A number of the telephones invented by Mr. Edison may be classed together as short-circuiting or

cut-out telephones. The principle upon which they act may be thus briefly stated: In vibrating, the diaphragm cuts from the circuit resistances which are proportional to the amplitude of the vibrations. A transmitter constructed upon this principle is shown in Fig. 16. A lever, *L*, of metal, vibrating in a vertical plane, rests at one end upon a strip of carbonized silk, *C*, which is part of the primary circuit of the induction-coil *I*. In the course of its vibrations the lever cuts from the circuit parts of the silk, the current passing temporarily through the lever.

Another, acting on the same principle, but differing considerably in construction, is shown in Fig. 17. A fine wire, *W*, of high resistance, is wrapped around a cylinder in a spiral groove.

The wire forms part of the primary circuit of the coil *C*. A spring, *S*, of metal, in the form of an ellipse, is fastened at one side to the diaphragm, while the other side presses against the uninsulated wire upon the cylinder. The diaphragm, in moving toward the right, flattens the spring, making it impinge upon a greater number of convolutions than it would if the motion were in the opposite direction. The resistance of the circuit depends, therefore, upon the position of the centre of the diaphragm. The disadvantage of this arrangement is, that either a whole convolution or none at all is suppressed from the circuit, rendering the current rather more intermittent than pulsatory.

In Fig. 18 a similar spring rests upon a narrow strip of metal on the surface of a glass plate. The film is shown in perspective at *F*, and consists of a fine strip of the silvered surface of a mirror, the rest of the burnished metal having been removed.

The action of this instrument is similar to that of the instrument shown in Fig. 16.

Still another form of short-circuiting telephone is shown in Fig. 19. A spiral spring, *W*, is wrapped about a cylinder, the diaphragm pressing against the last turn, so that in vibrating the convolutions approach or recede from each other. A very slight motion of the diaphragm is sufficient to cause the first few coils to come together; and in general the number of coils that thus touch each other is dependent upon the amplitude of the diaphragm's motion. The wire is included in the primary circuit of an induction-coil, so that the resistance of the circuit fluctuates as the diaphragm vibrates.

Condenser-Telephones.—Telephones in which static charge, instead of current strength, is made to vary in unison with the vocal utterances, have also been tried with success by Mr. Edison. The forms shown in Figs. 20 and 21 differ only in construction, not in principle.

The former consists of a circular vocalizing chamber, with mouthpiece at *V*. The chamber is surrounded with plates, which are connected with each other and to the ground. These plates are free to vibrate, and are shown in the figure in section, as at *P'*. Immediately

behind each of these stands a similar plate as at *P*, held at its centre by an adjusting screw. The outside row of plates is electrically connected with each other and with the battery, which goes to the line.

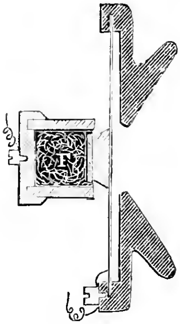


FIG. 15.

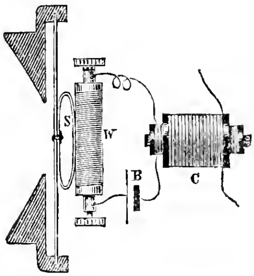


FIG. 17.

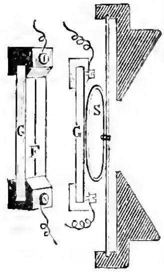


FIG. 18.

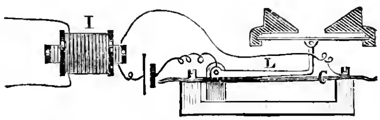


FIG. 16.

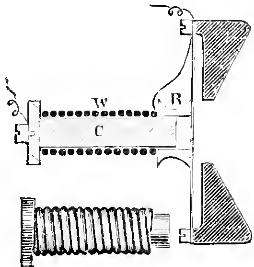


FIG. 19.

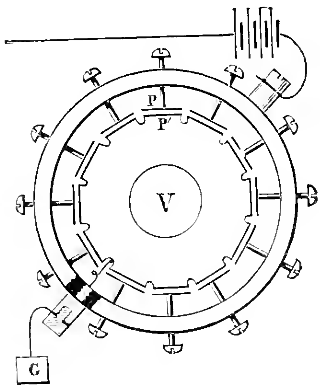


FIG. 20.

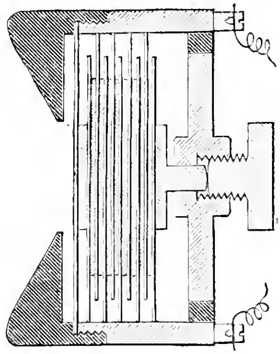


FIG. 21.

When the inside row of plates vibrates under the influence of a sound, the distance between the plates varies and changes their static capacity.

In Fig. 21 the plates are arranged as in the ordinary form of a condenser. An initial pressure is put upon them by a screw passing

through a portion of the solid frame of the instrument. The diaphragm in vibrating varies the distance between the plates. This alters their static charge, and affects also the electric tension of the line. The resistance of a conductor is dependent upon its shape. If an isometric block of metal be drawn out into a wire, its resistance may be indefinitely increased. This fact lies at the basis of several ingenious telephones invented by Mr. Edison. The one shown in Fig. 22 is of exceedingly simple construction. A globule of mercury, *M*, rests upon a slightly concave plate of metal. A needle from the diaphragm indents its upper surface, and, as it vibrates, slightly alters the shape of the globule. This alteration, though exceedingly small, is sufficient to vary the resistance of the telephonic current considerably.

It is a peculiar characteristic of a globule of mercury that it changes its original shape during the passage of a current through it. Mr. Edison has made an application of this phenomenon in the telephone-receiver shown in Fig. 23. The globule of mercury, *M*, is placed, together with a conducting solution, in a V-shaped tube. The currents from a transmitter, passing through the contents of a tube, elongate the mercury. This agitates the liquid and vibrates the float *F*, which is fastened to the centre of the diaphragm.

The Voltaic Pile Telephone.—We have shown in Fig. 24 an instrument known as the pile-telephone. A piece of cork, *K*, fastened to the diaphragm, presses upon a strip of platinum which is attached to a plate of copper. The latter is one of the terminal plates of an ordinary voltaic pile. The other terminal plate presses against the metallic frame of the instrument. When the pile is included in a closed tele-

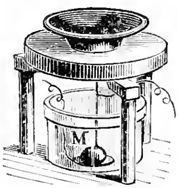


Fig. 22.

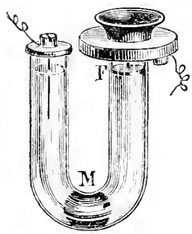


Fig. 23.

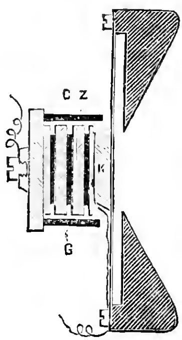


Fig. 24.

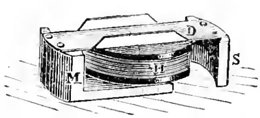


Fig. 25.

phonic circuit, it furnishes a continuous current. The strength of this current depends upon the internal resistance of the pile, and the latter is varied by vibrating the diaphragm.

A convenient and peculiar form of receiver used by Mr. Edison is

shown in Fig. 25. It is like the ordinary magneto-telephone, except that the circular diaphragm is replaced by a strip of thin iron, the edges having been bent so as to render it stiff. We mention it, simply because it demonstrates the fact that it is not essential that the diaphragm be circular.

A novel and purely mechanical telephone is illustrated by Fig. 26. In place of a line-wire, the illuminating gas, contained in gas-pipes, is used. It is calculated for short distances only, as it is essential that

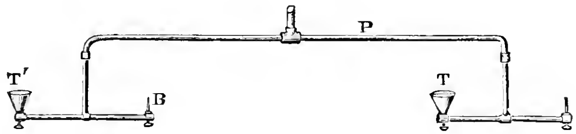


FIG. 26.

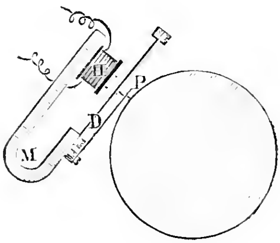


FIG. 27.

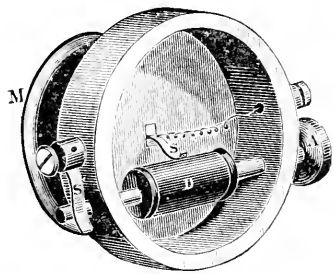


FIG. 28.

the gas used in communicating offices should be drawn from the same main pipe. In the figure, *P* is the main pipe. The telephones are represented at *T* and *T'*. The instrument is merely a cone fastened by its apex to the gas-pipe in place of the burner. The larger end is closed by a thin circular diaphragm. The vibrations are conveyed from one diaphragm to another through the medium of the gas.

The phonograph and telephone, when combined, form an instrument known as the telephonograph, of which Fig. 27 is a representation. The drum of the phonograph is shown in section. The diaphragm, instead of being vibrated by the voice, is vibrated by the currents which traverse the helix, *H*, and which originate at a distant station. The object of the instrument is to obtain a record of what is said at the distant office, which can be converted into sound when desired.

THE MOTOGRAPH.—The motograph-receiver, from which we have been accustomed to hear sounds almost destitute of quality, has, by a little modification, become an articulating telephone. It works quite well in conjunction with the Edison carbon-transmitter. In Fig. 28 the back of the motograph-receiver has been removed, showing its construction. Within the drum *D* is contained the decomposing solution,

and the covering surrounding the drum is kept constantly moits by capillary action. A metallic spring attached to the centre of the diaphragm rests upon the drum; while receiving, the drum is revolved by turning the milled screw at *A*.

A new transmitter for the motograph is shown in Fig. 29. The point *P*, projecting from the centre of the diaphragm, impinges upon a wrapping of plumbagoed silk, covering a small drum capable of adjustment by a thumb-screw.

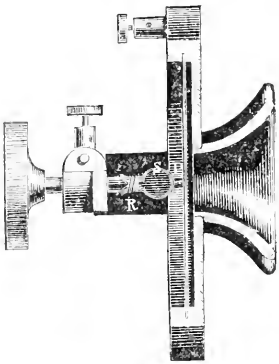


FIG. 29.

THE CARBON-RHEOSTAT.—A very important application of the property possessed by semi-conductors of changing their resistance under varying pressure, is shown in Fig. 30. The cut represents the new Edison carbon-rheostat. The instrument is designed to replace the ordinary adjustable rheostats whenever a resistance is to be inserted in a telegraph-line; as, for example, in balancing quadruplex circuits.

Fig. 31 is a vertical section. It shows a hollow cylinder of vulcanite, containing fifty disks of silk that has been saturated with sizing, and well filled with fine plumbago and dried. These are surmounted by a plate of metal, *C*, which can be raised or lowered by turning the

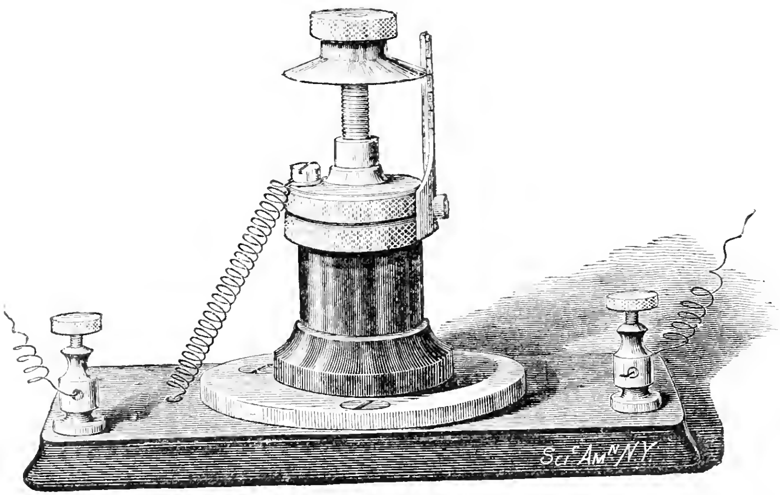


FIG. 30.

screw *D*. The carbon-disks can thus be subjected to any degree of pressure at pleasure. When inserted in the line, it is a matter involving no loss of time to obtain any desired resistance. The resistance can be varied from 400 to 6,000 ohms.

THE TASIMETER.—Fig. 32 shows in perspective the latest form of the Edison microtasimeter, or measurer of infinitesimal pressure. The value of the instrument lies in its ability to detect small variations of temperature. This is accomplished indirectly. The change of temperature causes expansion or contraction of a rod of vulcanite, which changes the resistance of an electric circuit by varying the pressure it exerts upon a carbon-button included in the circuit. During the total eclipse of the sun, July 29, 1878, it successfully demonstrated the existence of heat in the corona. It is also of service in ascertaining the relative expansion of substances due to a rise of temperature.

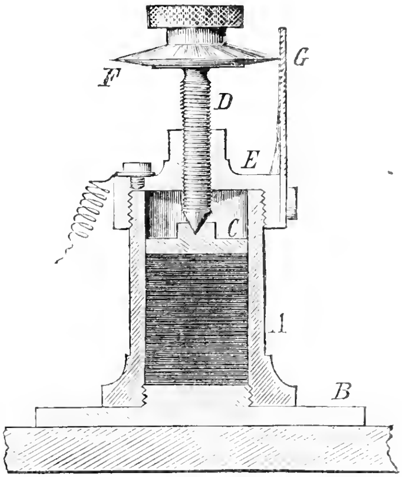


FIG. 31.

In Fig. 33 the important parts are represented in section, affording an insight into its construction and mode of operation.

The substance whose expansion is to be measured is shown at *A*. It is firmly clamped at *B*, its lower end fitting into a slot in the metal

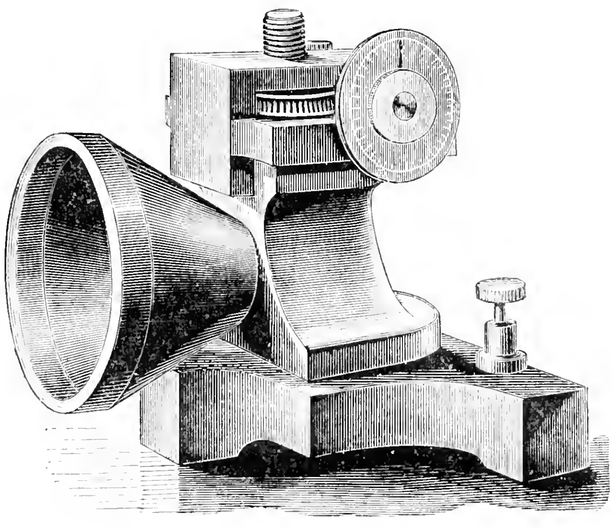


FIG. 32.

plate, *M*, which rests upon the carbon-button. The latter is in an electric circuit, which includes also a delicate galvanometer. Any variation

in the length of the rod changes the pressure upon the carbon, and alters the resistance of the circuit. This causes a deflection of the galvanometer-needle—a movement in one direction denoting expansion of *A*, while an opposite motion signifies contraction. To avoid any deflection which might arise from change in strength of battery, the tasimeter is inserted in an arm of the Wheatstone's bridge.

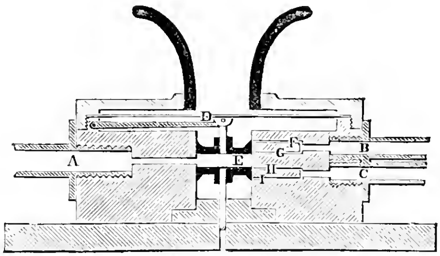


Fig. 33.

In order to ascertain the exact amount of expansion in decimals of an inch, the screw *S*, seen in front of the dial, is turned until the deflection previously caused by the change of temperature is reproduced. The screw works a second screw, causing the rod to ascend or descend, and the exact distance through which the rod moves is indicated by the needle, *N*, on the dial. The instrument can also be advantageously used to measure changes in the humidity of the atmosphere.

In this case the strip of vulcanite is replaced by one of gelatine, which changes its volume by absorbing moisture.

The Arephone.—The arephone, an invention of Mr. Edison's, for amplifying sound, has already attracted considerable attention, though as yet it has not been perfected.

Its object is to increase the loudness of spoken words, without impairing the distinctness of the articulation.

The working of the instrument is as follows: The magnified sound proceeds from a large diaphragm, which is vibrated by steam or condensed air. The source of power is controlled by the motion of a second diaphragm, vibrating under the influence of the sound to be magnified.

There are three distinct parts to the instrument:

A source of power—compressed air.

An instrument to control the power.

A diaphragm vibrating under the influence of the power.

The first of these is usually compressed air, supplied from a tank. It is necessary that it should be of constant pressure.

The second, shown in section at Fig. 34, consists of a diaphragm and mouth-piece, like those used in the telephone. A hollow cylinder is attached by a rod to the centre of the diaphragm. The cylinder, and its chamber, *E*, will therefore vibrate with the diaphragm.

A downward movement lets the chamber communicate with the outlet *H*, an upward movement with the outlet *G*. The compressed air enters at *A*, and fills the chamber, which, in its normal position, has no outlet. Every downward vibration of the diaphragm will thus con-

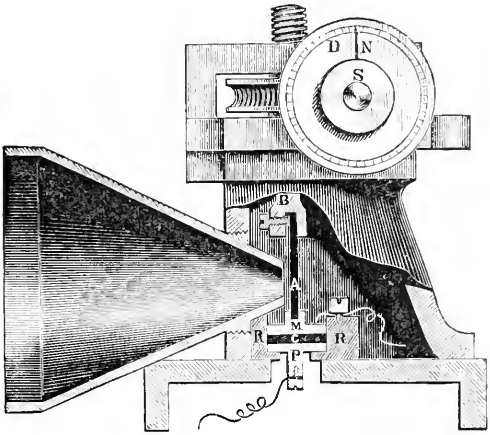


FIG. 34.

dense the air in the pipe *C*, at the same time allowing the air in *B* to escape *via F*. An upward movement condenses the air in *C*, but opens *I*.

The third and last part is shown in section in Fig. 35. It consists of a cylinder and piston, *P*, like that employed in an ordinary engine.

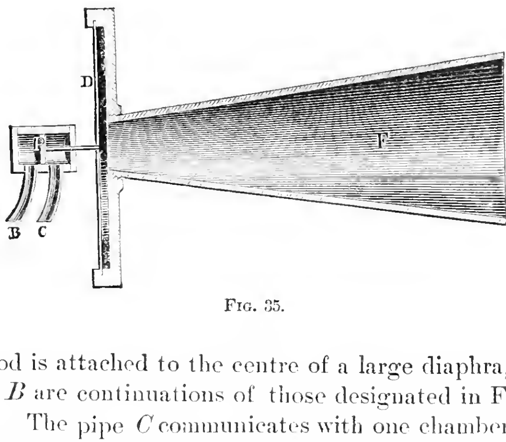


FIG. 35.

The piston-rod is attached to the centre of a large diaphragm, *D*. The pipes *C* and *B* are continuations of those designated in Fig. 34 by the same letters. The pipe *C* communicates with one chamber of the cylinder, and *B* with the other. The piston, moving under the influence of the compressed air, moves also the diaphragm, its vibrations being, in number and duration, identical with those of the diaphragm in the mouth-piece.

The loudness of the sound emitted through the directing tube, *F*, is dependent on the size of the diaphragm and the power which moves it. The former of them is made very large, and the latter can be increased to many hundred pounds' pressure.

The Harmonic Engine.—This instrument is shown in Fig. 36. Mr. Edison claims that ninety per cent. of the power derived from the battery is utilized through its agency. The parts of the machine are: a tuning-fork of large dimensions, vibrating about thirty-five times a second, and carrying on each arm a weight of thirty-five pounds. The amplitude of the vibration is about one-eighth of an inch, and the vibrations are sustained by means of two very small electro-magnets, placed near the end of each arm. These magnets are connected in circuit with each other, and with a commutator worked by one of the arms.

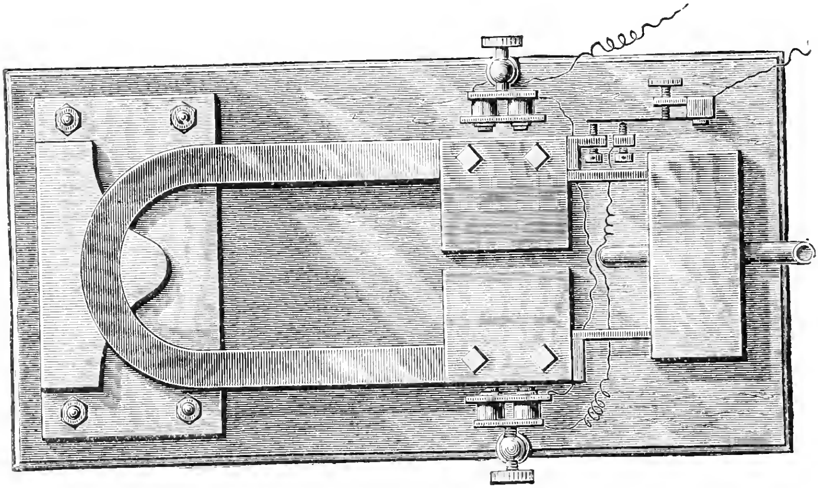


Fig. 36.

Small branches extend from the fork-arms into a box containing a miniature pump having two pistons, one attached to each arm. Each stroke of the pump raises a very small quantity of water, but this is compensated for by the rapidity of the strokes. Mr. Edison proposes to compress air with the harmonic engine, and use it as a motor for propelling sewing-machines and other light machinery. It appears to be considerably in advance of other electric engines, and through its agency electricity may yet become a valuable motive-power.

FEVER-FACTORIES.

By F. L. OSWALD, M. D.

THE prediction of the *New Orleans Medical Journal*, that the vital and material losses of the Southern States by the last epidemic would exceed the costs of our Mexican War,[1] has been fully verified, but by its very magnitude the calamity may prove a less unqualified evil if it should help to open our eyes to the true nature and the origin of what has too long been considered a mysterious and unavoidable plague.

The hope of solving the riddle of the periodicity and topographical predilections of the fever-fiend suggested a careful comparison of the pathological statistics of our Spanish-American neighbors with those of our Southern lowlands; and these studies have revealed some curious facts, which the correspondents of our medical periodicals have corroborated rather than explained.

It appears that a disease which our ablest physicians have described as intensified malaria, has by no means confined itself to the malarious, i. e., swampy regions of the Atlantic slope, but in a great majority of cases may be traced to a city, or a well-drained but thickly-populated district, where the dietetic and domestic habits of the Caucasian race predominate over those of the American aborigines. Among many of the Indian tribes that inhabit the marshy lowlands and humid coast-forests of our continent, fevers are, on the other hand, wholly unknown; while Europeans who visit such regions, or natives who adopt European modes of life, become liable to a variety of enteric disorders.

Vera Cruz, *la Ciudad de los Muertos*, "the City of the Dead," as the Mexicans call it, on account of the frequency of its yellow-fever epidemics, is situated on a barren and extremely dry coast, remote from all swamps, and surrounded by arid sand-hills; while the natives of the peninsula of Yucatan, with its swamps and inundated virgin forests, are considered to be the healthiest and hardiest portion of the Mexican population. La Guayra, Caracas, and Santiago de Cuba, in spite of their mountainous environs, complain of the terrible regularity of their autumnal epidemics; but in the valley of the Amazon fevers were unknown before the arrival of the European colonists, and are still monopolized by the creoles and negroes of the larger settlements. The forest tribes of the Madeira, says Bonpland, cautioned the mis-

[1] The territorial acquisitions of the United States in 1848 were achieved at a cost of 15,350 human lives, and a direct and indirect expense of $123,000,000—a sum which was more than repaid by the California revenues of the next ten years. Total deaths by yellow fever from August 5 to October 5, 1878, 17,012. Direct and indirect losses (without any prospective compensation) of the city of New Orleans alone, $16,000,000—about one-tenth of the loss total to the Mississippi Valley from Memphis to the Delta.

sionaries against the use of animal food, and warned them that it would produce a disease which, like original sin, could only be cured by baptism, i. e., frequent shower-baths and invocations of the Great Spirit; and Bernal Diaz tells us that the subjects of Montezuma were afflicted with an eruptive disease, more painful though less incurable than leprosy, but that fevers made their first appearance with the Spaniards, and were long limited to the district of Toltepec (in the valley of Anahuac) and the Spanish quarter of the city of Tlascala.

In our cotton States, too, Baton Rouge, Vicksburg, and Memphis, on their high and dry bluffs, and Chattanooga, at an elevation of seven hundred feet above the level of the Gulf, have suffered more in proportion to their population than any place this side of Vera Cruz; while the swamps of the Red River and the Arkansas bottom-lands had not much to complain of besides their chronic "chills," and the *ne-plus-ultra* swamp, called Florida, has been entirely spared.

It is also known that the miasmatic virulence of alluvial districts is aggravated by excessive moisture and diminished by dry seasons, especially long, dry summers, which convert festering bogs into harmless steppes, and confine the swamp-belt of large rivers to a narrow strip along the lower shores. Now, if yellow fever, typhus, and cholera, were depending upon what physicians call telluric causes, i. e., the condition of the soil, in our more or less immediate neighborhood, wet years would be the most dangerous, whereas experience shows that, on the contrary, epidemics generally follow upon dry, hot summers, like the last and those of 1873 and 1868. These facts, which agree with the experience of the remotest countries and times, only confirm what dietetic reasons might indicate *a priori*, viz., that the so-called zymotic diseases have subjective rather than objective causes: they are produced by the unhealthy condition, not of the country so much as of the inhabitants, and originate in dry cities oftener than in swampy forests.

During the long centuries of the *Juventus Mundi*, forests and swamps were almost synonyms, as they still are in the lower latitudes of America and Eastern Asia. Animal life swarms and revels in such regions. Herbivorous and carnivorous animals, and our cousins the anthropoid apes, thrive in the moist woodlands of the torrid zone, and the Asiatic Malays, the natives of Soodan and Senegambia, and the aborigines of our own continent, have inhabited the swampiest districts of the tropical bottom-lands for ages with perfect impunity. They do not employ any of the antidotes by which the stranger hopes to secure himself against what he calls climatic influences, and that their immunity is not the inherited privilege of a special race is demonstrated by the diseases of the Mexican Indians, who have adopted the diet of their Spanish masters, and of the West African negroes, who have been carried to the far less swampy islands of the West Indian Archipelago. Dietetic differences alone can, therefore, furnish a logical

explanation, and these differences may be comprised in a few words: the savages of the tropics avoid calorific food.

Like their next neighbors, the Hindoos, the natives of Siam and the Sunda-Islanders are mostly frugivorous. Rice, fruits, nuts, and milk, constitute their principal diet, and only famine can reduce them to the use of animal food; they eschew the sudorific drinks of their European masters, and their only stimulant is a cooling alkaloid, the coagulated juice of the betel-nut palm, which they chew with an admixture of shell-lime. The mountaineers of Abyssinia and the inhabitants of the chilly South African highlands are carnivorous; but the natives of Guinea and Soodan, like the Arabs of the Desert, keep cattle and sheep for the sake of their milk, and use their flesh only in times of scarcity or in war. Our Spanish neighbors divide the copper-colored race into two well-defined classes, the *Indios Mansos* and the *Indios Bravos*, "the tame and ferocious Indians:" the first the frugal, Hindoo-like inhabitants of the coast-forests from Yucatan to Peru; the second the cruel hunters of men and beasts, who roam the wilds of the great West and the table-lands of Northern Mexico and Patagonia. The *Indios Mansos* of Yucatan, for instance, live on bananas, corn-cakes, brown beans fried with a little butter or palm-oil, and the abundant berries and nuts of their native forests, and enjoy an exceptional longevity and freedom from all sicknesses whatever, in all of which respects they resemble the ancient Peruvians, who had no physicians, as Devega remarks, because their only sickness was an incurable one—old age.

Instinct teaches these savages what our science seems to have forgotten, viz., that we must not aggravate the effects of atmospheric heat by calorific artifices. Almost all the domestic habits which distinguish the weaving and house-building Caucasian from the naked savage were originally precautions against the inclemency of a frigid latitude; and it is perhaps the greatest mistake of modern civilization that these precautions have become permanent institutions, instead of being confined to the winter season and occasional cold nights in April and October. We counteract the effects of a low temperature by artificial supplements to our native skin, by weather-proof buildings and heat-producing food, and with such success that De Quincey could define comfort as a supper eaten at leisure in a chimney-corner during the fiercest storm of a November night; but, when the dog-star rules the season, these factitious comforts turn to a very positive misery, and the same contrivances that shelter us against the fury of the snow-storm exclude the breezes that would temper the glow of the summer sun.

All the conventional, anti-natural customs of our social life, and all the prejudices of our prudish morality, seem to conspire to make the sunny half of the year as uncomfortable as possible. In a temperature that makes us envy the external lungs of the zoöphytes, and seethes

our veins till we would gladly part with our hereditary cuticle, custom obliges us to invest ourselves in double and threefold garments—air-tight if not water-proof, some of them—which intensify the effects of the atmospheric heat by the retained animal warmth of our own bodies, and confine, not perspiration, but the benefits of perspiration, to the small uncovered portion of our skin.

Our cities are atmospheric bake-ovens. They exclude the horizontal air-currents that sweep freely through the shady arcades of the forest, but they admit sunlight and retain their self-created heat, their dust, and their sudorific vapors. We have inherited the antique passion for whitewashed houses and stone fences that reflect the sun's rays with a distressing glare, while we have abolished the intramural gardens and free public baths that alleviated the summer sufferings of the ancient Mediterranean cities; but our hyperborean diet is perhaps a still more prolific source of evil.

The experience of all tropical and sub-tropical nations has taught them to avoid animal food and fat, and to counteract the influence of a sultry climate by cooling, non-stimulating drinks and fruit, for a three or four years' neglect of these precautions is sure to undermine the soundest constitution, as demonstrated by the fate of countless employés of the East Indian administration, who left Great Britain as models of Saxon or Celtic *vis virilis*, and returned as tremulous invalids after a few hundred beefsteak-and-ale dinners in the atmosphere of the Lower Ganges Valley. The advent of our autumnal night frosts and bracing north winds saves most of us from the ultimate consequences of this East Indian malady, but not one man in a thousand escapes the *pro tempore* penalties of living through the tropical quarter of the solar year as if he were fighting the battle of life against an arctic snow-storm. Cold air is a tonic and antiseptic, and under its influence many substances which Nature never intended for our food become healthy or at least digestible, for a Kamtchatka fisherman can swallow as his daily ration a dose of blubber and brandy that would kill seven Hindoos. The pork-steaks and bitters that feed the fire of life in December smother it in August like so much incombustible rubbish, or evolve fumes that obscure its brightness, till we yearn for the equinoctial gale like a becalmed mariner in a fog, or take refuge from hypochondria in the summerless heights of a mountain-region; and, if starvation were not so often superadded to the cold and the darkness of the season of short days and long nights, it would be very doubtful if the bitterest winter sorrows of the children of Nature could compare with the self-inflicted summer martyrdom of a European or North American dyspeptic. For languor, dull headaches, nausea, and troubled dreams, though singly and momentarily no very serious evils, can aggregate in a sum of misery that has induced all northern nations to make a high temperature the chief characteristic of the pit of torment.

The antidotal resources of Nature counteract the evil for a while ; diarrhœa, retching, and intermittent fevers, discover her efforts to secrete an indigestible substance ; the suicidal diet is modified, in quantity at least, by nausea and loss of appetite, and the periodical north winds that reduce the summer temperature of our Southern States by twenty or thirty degrees may help to postpone the crisis for weeks and months. But if that palliative fails, and the devotee of established customs pursues his course with intrepid fanaticism, the barriers of life yield at last, and Nature ends an evil which she cannot cure. The direct cause of yellow fever is the inability of the vital power to withstand the double influence of moist heat from within and without.

In all zymotic diseases the blood passes through the incipient stages of fermentation, incited, perhaps, by floating animal or vegetable germs, but favored by and depending upon the enteric condition of each individual. The morbid humors begin to ferment,[1] the progress of decomposition separates the red blood-globules from the serum ; the first accumulate in the digestive apparatus and are discharged in that vomit of cruor which marks the advanced stages of yellow fever and cholera, while the absence of the coloring particles from the circulating blood tinges the skin with a yellowish hue. The convulsion of the bowels reacts on the brain, produces violent headaches, coma, perhaps, or delirium, and paroxysms of nausea, and ends by utter exhaustion and death. It is notorious that the bodies of the victims of yellow fever need immediate interment on account of the swiftness with which putrefaction begins, or rather ends, its work.

As its name implies, a fever epidemic is a contagious disease, and it cannot be denied that by prompt removal from the infected atmosphere innumerable candidates of the winding-sheet might be saved ; but it is quite as certain that even persons of a frail constitution, but innocent of dietetic sins, may breathe with impunity the air in which thousands of their stricken fellow-citizens have recently expired. Everywhere the mortality lists show a great preponderance of males over females, of men of sedentary pursuits over open-air laborers, and of epicures over ascetics. Catholic seminarists, Sisters of Charity, vegetarians, and tramps, have enjoyed a remarkable immunity, owing to their voluntary or involuntary habits of abstinence. Worried physicians, spectral old spinsters, and smoke-dried presbyters, have generally survived, while corpulent beer-brewers, lusty landlords, and chubby butcher-boys, went down like grass under a sweeping scythe ; and the local papers of New Orleans and Vicksburg have repeatedly called attention to the fact that the business-men who declined to close either their earthly career or their stores were mostly Italians and Jews.

The lessons of the last epidemic find numerous precedents in the

[1] That the blood-changes in zymotic diseases are *catalytic* is sufficiently proved by the prophylactic power of cold and of the same antiseptics that would arrest an inchoate process of fermentation.

history of former times. The *black-death* that ravaged Asia and Southern Europe in the fourteenth century spared the Mohammedan countries—Persia, Turkistan, Morocco, and Southern Spain—whose inhabitants generally abstained from pork and intoxicating drinks. In the Byzantine Empire, Russia, Germany, France, Northern Spain (inhabited by the Christian Visigoths), and Italy, 4,000,000 died between 1373 and 1375, but the monasteries of the stricter orders and the frugal peasants of Calabria and Sicily enjoyed their usual health (which *they*, of course, ascribed to the favor of their tutelar saints); but among the cities which suffered most were Barcelona, Lyons, Florence, and Moscow, the first three situated on rocky mountain-slopes, with no lack of drainage and pure water, while the steppes of the Upper Volga are generally dry and salubrious.

The pestilence of 1720 swept away 52,000, or more than two-thirds of the 75,000 inhabitants of Marseilles, in less than five weeks; but of the 6,000 abstemious Spaniards that inhabited the "Suburb of the Catalans" only 200 died, or less than four per cent. The most destructive epidemic recorded in authentic history was the four years' plague that commenced in A. D. 542 and raged through the dominions of Chosroes the Great, the Byzantine Empire, Northern Africa, and Southwestern Europe. It commenced in Egypt, spread to the east over Syria, Persia, and the Indies, and penetrated to the west along the coast of Africa and over the Continent of Europe. Asia Minor, with its plethoric cities, Constantinople, Northern Italy, and France, suffered fearfully; entire provinces were abandoned, cities died out and remained vacant for many years, and during three months 5,000 and at last 10,000 persons died at Constantinople *each day!* (Gibbon's "History," vol. iii., chap. xliii.); and the total number of victims in the three continents is variously estimated from 75,000,000 to 120,000,000 (Procopius, "Anecdot.," cap. xviii.; Cousin's "Hist.," tome ii., p. 178). But in Sicily, Morocco, and Albania, the disease was confined to a few seaport towns, and the Caucasus and Arabia escaped entirely.

This dreadful plague made its first appearance in Alexandria, Egypt, then a luxurious city of 800,000 inhabitants, and Paulus Diaconus, a contemporary historian, speaks of the "reckless gluttony by which the inhabitants of the great capital incurred yearly fevers and dangerous indigestions; and at last brought this terrible judgment upon themselves and their innocent neighbors" (lib. ii., cap. iv.). Alexandria lost half a million of her inhabitants in 542, and 80,000 in the following year, and for miles around the city the fields were covered with unburied corpses; but the monks of the Nitrian Desert (3,000 of them had devoted themselves to the task of collecting and burying the dead) lost only fifty of their fraternity, who with few exceptions confessed that they had secretly violated the ascetic rules of their order.

If the thirteen centuries since that year of judgment had been employed in the study of physiology and hygiene rather than in Trinita-

rian and Monophysite disputes and transubstantiation controversies, we might know by this time that the repetition of the excesses of the Egyptian capital in an Egyptian climate will always provoke an Egyptian plague, and that the observance of some simple dietetic rules would insure our health against the most malignant climatic influences. Southern cities like New Orleans, Memphis, and Galveston, that consume from 500 to 5,000 barrels of pork and four times as many kegs of lager-beer and gallons of whiskey each summer day, while they confine forty or fifty per cent. of their population in stifling tenement-houses, schoolrooms, and workshops, and, instead of providing free public baths, legislate against river-bathing within their corporate limits—such cities, whether situated in the swamps, like New Orleans, or on dry hills, like Memphis, are fever-factories, and produce epidemic diseases by the use of calorific food in a sweltering climate, as systematically as the New Orleans ice-factory evolves cubes of congealed water by the evaporation of ether in and around its copper water-tanks.

To our dietetic abuses and the deficient ventilation of our buildings and *bodies*, we can ascribe the fact that the average mortality of the half-year from June to November exceeds that of the remaining six months by twenty per cent. on the table-lands and by more than thirty per cent. along the sea-coasts of the two Caucasian continents; but this increase of the death-rate is only a small part of the sum total of our self-caused summer martyrdom. If we could weigh the nameless discomforts, the weariness, the physical and moral nausea, and the unsatisfied hunger after the life-air and freedom of the wilderness, endured by millions of factory-children, shopkeepers, and counting-house drudges, if we could weigh all their misery against the hardships of the savages and half-savage nomads, we might agree with the Benthamites, that, measured by the criterion of the greatest happiness of the greatest number, modern civilization is a very indifferent success. "There is something pathetic in every suicide," says Montesquieu, "for the fact that life had become insupportable to a human being could not be more conclusively proved." But the same fact is proved by every premature death, for the destructive agencies of Nature never assert themselves till the evils of life outweigh its blessings. When Vishnu resigns his power to Shiva we may be sure that annihilation is the more merciful alternative.

A privileged small minority, some happy few among the upper ten per cent. of our city population, can celebrate the holidays of their luxurious year, when rising thermometers, dust-clouds, kitchen-fumes, woolen garments, and peppered ragouts, kindle the fires of Moloch in our veins; but what shall we do to be saved if poverty or duty prevent us to save ourselves by flight to the White Mountains? A century may pass before chemists invent the art of cooling our houses by an artificial process as cheaply and effectually as we warm them by fire,

but in the mean time we might restrict our calorific efforts to the eight coolest months of the year.

In the first place we might curtail the number of our warm meals, or cook them on the coöperative plan in a separate building, where ten or twelve families could use a common stove and a joint stock of fuel and certain groceries, and thus save our sitting-rooms and studies from the effects which even a basement-kitchen fire exerts on the domestic atmosphere. Heat-producing food, too, might very well be dispensed with. The vegetarian school has demonstrated beyond the possibility of a doubt that farinaceous dishes, sweet milk, and fruit, are sufficient to maintain a hard-working man in perfect health, and such a diet might certainly be substituted for our greasy steaks and ragouts during the hottest weeks of the sultry season. Whether or not such mild stimulants as tea and coffee are preferable to pure water, it is certain that they are sudorific drinks, and that even their moderate use increases the temperature of our blood by several degrees during their passage through the digestive apparatus. Smoking-hot dishes and such spices as pepper, mustard, onions, and ginger, are liable to the same objection, and we should not forget that sultry weather retards the digestion of all fatty substances by several hours.

Cooling and non-stimulating drinks of a temperature of not less than 5° above the freezing-point might, on the contrary, be freely used in any enjoyable quantity, for the prevailing notions in regard to the danger of "cold drinks in the heat" prove nothing but the marvelous tenacity of popular superstitions. Like the prejudice against raw fruit, night air, and "draught" (i. e., the passage of a current of pure air through the vitiated air of a human dwelling), this notion has furnished a pretext for the strangest sanitary aberrations, and has been defended with the same ingenious sophistry that supplies the advertisers of patent nostrums with their specious arguments. To prevent cold water from "chilling our stomachs," we are advised to mix it with a few drops of brandy, to wash our wrists and let our faces cool off, or to chew a preliminary bread-crust; and parents solemnly warn their children not to endanger their health by gratifying an imprudent appetite.

But the craving of our heated system for a refrigerating beverage is a natural instinct which we share with all warm-blooded animals, and which manifests itself in children and savages as well as in adult and civilized men. We see horses, hounds, and stags, walk bodily into a cool river after a hot chase, or quench their thirst at a cold spring with perfect impunity; and the idea that Nature should thus tempt us to anything positively injurious implies a deplorable ignorance of the language of our *physical conscience*. Injurious things, as poisons, excessive heat, or excessive cold, are disagreeable; and whatever is agreeable is beneficial, unless instinct has been supplanted by artificial habits. It might, for instance, be said that the appetite of a drunkard tempts

him to indulge in a body and soul destroying poison, but that appetite has been artificially and painfully acquired, and in spite of the earnest protests of Nature, which teach a child by the unmistakable testimony of its senses that alcohol and all fermented drinks are disgusting, and consequently injurious. But cold water, cold sweet milk, lemonade, and cider fresh from the press, are agreeable to every undepraved palate, and of these and similar beverages we might drink our fill on the hottest day, without any fear of having to repent the gratification of a *natural* appetite. Persons, like Baron Brisse, who frankly admit that their only object in life is to diminish its tedium, act at least consistently if they adopt the most effectual means to shorten its duration, but housekeepers who, from motives of economy, grudge their children a handful of apples or an excursion to a shady picnic-ground, should not boast of their annual savings before they have deducted the doctor's bill.

To take plenty of rest after meals is another health rule which we might adopt on the authority of our instinct-guided fellow-creatures, if not of our sensible ancestors, who surpassed us in physical vigor and hygienic insight as much as we exceed them in mechanical or astronomical knowledge. In obedience to an urgent instinct, wild animals retire to their hiding-places after a hearty feed, and digest in peace; and the ancient Greeks, as well as the Romans of the ante-Cæsarean era, contented themselves with one daily meal, which they ate leisurely in the cool of the afternoon after completing their day's work. The rest of the evening they devoted to music, conversation, dances, and light gymnastics, and had thus all night, besides the larger part of the following day, for digestion, could assimilate their food, and probably derived more enjoyment from that one meal than we do from our hurried dinners, late suppers, luncheons, and "Christian breakfasts"—true *déjeuners dinatoires,* that dull our brains and limbs during the first three or four post-prandial business-hours.

For a quarter of a year, at least, we might get along with two daily meals, one at noon, after finishing the larger and harder half of our day's work, on an "empty stomach" (which custom would soon make a resigned and very comfortable stomach), then a *siesta* of three or four hours; work till sunset, and then a bath, followed by a leisurely symposium and such domestic amusements as our tastes and opportunities might suggest; and since it is probably true that sleep should not follow too close upon a large meal, we might prolong our amusements or *dolce far nientes* through the first third of the night, on Saturdays even till after midnight, without fear of thereby violating any law of Nature. The habits of our next relations among the children of the wilderness, the mammals, and vertebrate reptiles, become semi-nocturnal during the warm season: deer, buffaloes, antelopes, and kangaroos, graze in moonshine; bears and foxes leave their dens after dark and rest through the warmer part of the day; alligators wander about

on *terra firma* in warm nights, and frogs continue their serenades till the morning wind chills them into silence and somnolence. The drowsy heat of the afternoon invites to slumber as the cool hours before the noon of night invite to music, reverie, or sentimental conversation, and our midsummer-night dreams would be no worse for a moonlight ramble on the mountains or in the garden-suburbs of a large city.

But "the best of all things is water, after all," was Pindar's motto, and should be our motto in summer-time, in regard to pure cold water, externally applied. In the crowded cities of the Atlantic seaboard and the Lower Mississippi Valley, whose summer temperature equals that of southernmost Europe, the lot of the hard-working classes would be exceedingly improved by the institution of free public baths. The citizens of the Roman Empire regarded their *thermæ* and their *balnea publica* as the chief criterion of a civilized town; and it is strangely characteristic of the metaphysical and anti-natural tendency of our ethical system that not one of our wealthy philanthropists ever thought of promoting the welfare of his native city by an establishment which an enlightened community should value as a common necessity rather than as a luxurious privilege.

The baths of Caracalla, which furnished the means of physical purification to tens of thousands, were certainly as useful—practically and morally—as the Serapion or the temple of Jupiter Capitolinus; and one per cent. of the wealth that has been expended on churches, Sunday-schools, foreign missions, and other attempts to secure the *post-mortem* felicity of the masses, would suffice to make their terrestrial existence far more endurable.

EDUCATION AS A SCIENCE.

By ALEXANDER BAIN, LL. D.,

PROFESSOR IN THE UNIVERSITY OF ABERDEEN.

VII.—THE EMOTIONS IN EDUCATION (*concluded*).

THE considerations stated in the previous article (*see* November MONTHLY) lead up to the final subject—Punishment; in administering which the practice of education, as well as of other kinds of government, has greatly improved. The general principles of punishment have been already renounced. We have to consider their application to the school. But first a few words on the employment of reward.

EMULATION—PRIZES—PLACE-TAKING.—All these names point to the same fact and the same motive—the desire of surpassing others, of gaining distinction; a motive that has already been weighed. It is the most powerful known stimulant to intellectual application; and,

where it is in full operation, nothing else is needed. Its defects are (1) it is an anti-social principle, (2) it is apt to be too energetic, (3) it is limited to a small number, (4) it makes a merit of superior natural gifts.

It is a fact that the human intellect has at all times been spurred to its highest exertions by rivalry, contest, and the ambition of being first. The question is, whether a more moderate pitch of excellence, such as befits average faculties, could not be attained without that stimulant. If so, there would be a clear moral gain. Be this as it may, there is no need to bring it forward prematurely, or to press its application at the beginning. In the infant stage, where the endeavor is to draw out the amieable sentiments, it is better kept back. For tasks that are easy and interesting, it is unnecessary. The pupils that possess unusual aptitude should be incited to modesty rather than to assumption.

The greater prizes and distinctions affect only a very small number. Place-capturing, as Bentham phrases it, affects all more or less, although in the lower end of a class position is of small consequence. Too often the attainments near the bottom are *nil.* A few contesting eagerly for being first, and the mass phlegmatic, is not a healthy class.

Prizes may be valuable in themselves, and also a token of superiority. Small gifts by parents are useful incitements to lessons; the school contains prizes for distinetion that only a small number can reach. The schoolmaster's means of reward is chiefly confined to approbation, or praise, a great and flexible instrument, yet needing delicate manipulation. Some kinds of merit are so palpable as to be described by numerical marks. Next, in point of distinctness, is the fact that a thing is right or wrong, in part or in whole ; it is sufficient approbation to pronounce that a question is correctly answered, a passage properly explained. This is the praise that envy cannot assail. Most unsafe are phrases of commendation; much pains is needed to make them both discriminating and just. They need to have a palpable basis in facts. Distinguished merit should not always be attended with pæans; silent recognition is the rule, the exceptions must be such as to extort admiration from the most jealous. The controlling circumstance is the presence of the collective body; the teacher is not speaking for himself alone, but directing the sentiments of a multitude, with which he should never be at variance; his strictly private judgments should be privately conveyed. Bentham's "scholar-jury principle," although not formally recognized in modern methods, is always tacitly at work. The opinion of the school, when at its utmost efficiency, is the united judgment of the head and the members, the master and the mass. Any other state of things is war: although this, too, may be unavoidable.

PUNISHMENT.—The first and readiest, and ever the best, form of punishment, is censure, reprobation, dispraise, to which are applicable

all the maxims above laid down for praise. Definite descriptions of definite failures, without note or comment, are a power to punish. When there are aggravations, such as downright carelessness, a damaging commentary may be added; but, in using terms of reprobation, still more strict regard has to be paid to discrimination and justice. The degrees of badness are sometimes numerical, as by the quantity of lesson missed, and the repetition of inattention; this very definiteness literally stated is more cutting than epithets.

Strong terms of reproof should be sparing, in order to be more effective. Still more sparing ought to be tones of anger. Loss of temper, however excusable, is really a victory to wrong-doers; although for the moment it may strike terror. Unless a man is of fiendish nature throughout, he cannot maintain a consistent course, if he gives way to temper. Indignation under control is a mighty weapon. Yet it is mere impotence to utter threats when the power of execution is known to be wanting. There is nothing worse for authority than to overvaunt itself; this is the fatal step to the ridiculous.

Whoever occupies a position of authority ought to be familiar with the general principles and conditions of punishment, as they may be found set forth in the penal code of Bentham. The broad, exhaustive view there given will coöperate beneficially with each one's actual experience. I make no apology for presenting a short summary of his principles.

After precisely defining the proper ends of punishment, Bentham marks the cases unmeet for punishment: 1. Where it is *groundless:* that is, where there never has been any real mischief (the other party consenting to what has been done), or where the mischief is overweighed by a benefit of greater value. 2. Where it is *inefficacious:* including cases where the penal provision has not come before the offender's notice, where he is unaware of the consequences of his act, or where he is not a free agent. 3. Cases where it is *unprofitable:* that is, when the evil of the punishment exceeds the evil of the offense. (The evils of punishment, which have to be summed up and set against the good, are (1) coercion or restraint, (2) the uneasiness of apprehension, (3) the actual suffering, (4) the suffering caused to all those that are in sympathy with the person punished.) 4. Cases where punishment is *needless:* as when the end can be attained in some cheaper way, as by instruction and persuasion. In this class Bentham specially includes the offenses that consist in disseminating pernicious principles in politics, morality, or religion. These should be met by instruction and argument, and not by the penalties of the law.

Under what he calls the expense or frugality of punishment, Bentham urges the necessity of presenting to the mind an adequate notion of what a punishment really is. Hence the advantage of punishments that are easily learned and remembered, and that appear greater and not less than they really are.

Next as to the main point, the *measure* of punishment: 1. It should be such as clearly to outweigh the profit of the offense: including not simply the immediate profit, but every advantage, real or apparent, that has weighed as an inducement to commit it. 2. The greater the mischief of the offense, the greater is the expense that it is worth while to be at, in the way of punishment. 3. When two offenses come into competition, the punishment for the greater should be such as to make the less preferred; thus robbery with violence to the person is always punished more severely than simple robbery. 4. The punishment to be so adjusted that, for every part of the resulting mischief, a motive may be provided to restrain from causing it. 5. The punishment should not be greater than is needed for these ends. 6. There should be taken into account the circumstances affecting the sensibility of the offenders, so that the same punishment may not operate unequally; as age, sex, wealth, position. 7. The punishment needs to be increased in magnitude as it falls short of certainty. 8. It must be further increased in magnitude as it falls short in point of proximity. Penalties that are uncertain and those that are remote correspondingly fail to influence the mind. 9. When the act indicates a *habit*, the punishment must be increased so as to outweigh the profit of the other offenses that the offender may commit with impunity: this is severe, but necessary, as in putting down the coiners of base money. 10. When a punishment well fitted in its quality cannot exist in less than a certain quantity, it may be of use to employ it, although a little beyond the measure of the offense: such are the punishments of exile, expulsion from a society, dismissal from office. 11. This may be the case more particularly when the punishment is a moral lesson. 12. In adjusting the quantum, account is to be taken of the circumstances that render all punishment unprofitable. 13. If, in carrying out these provisions, anything occurs tending to do more harm than the good arising from the punishment, that thing should be omitted.

In regard to the selection of punishments, Bentham lays down a number of tests or conditions whereby they are fitted to comply with the foregoing requirements: 1. The quality of *variability:* a punishment should have degrees of intensity and duration; this applies to fines, corporal punishment, and imprisonment, also to censure or ill-name. 2. *Equability*, or equal application under all circumstances: this is not easy to secure; a fixed fine is an unequable punishment. 3. *Commensurability:* that is, punishments should be so adapted to offenses that the offender may clearly conceive the inequality of the suffering attached to crimes of different degrees of heinousness; this property can be grafted on the variable punishments, as imprisonment. 4. *Characteristicalness:* this is where something can be found in the punishment whose idea exactly fits the crime. Bentham dilates upon this topic, in order to discriminate it from the old crude method of an eye for an eye; cases in point occur abundantly both in the family and

in the school. 5. *Exemplarity:* this is connected with the impressiveness of a punishment; all the solemnities accompanying the execution increase this effect. Bentham, however, did not sufficiently consider the evils attending too great publicity, which have led to withdrawing punishments from the gaze of the multitude; it being simply intimated that they have been carried out. 6. *Frugality:* or making punishments less costly to the state, as when prisoners are employed productively. 7. *Subserviency to reformation:* by weakening the seductive and strengthening the preserving motives; as in giving habits of labor to the idle. 8. *Efficacy in disablement:* as in deposition from office. 9. *Subserviency to compensation:* as by pecuniary inflictions. 10. *Popularity.* Bentham lays much stress upon the popularity and unpopularity of punishments, whereby the public sympathy may work for or against the law; when a punishment is unpopular, juries are reluctant to convict, and public agitation gets up for remission of sentence. 11. *Simplicity of description:* under this head Bentham comments upon the obscure and unintelligible descriptions of the old law, as *capital felony*, *præmunire.* 12. *Remissibility*, in case of mistake.

Punishments must go deeper than words; indeed, the efficacy of blame depends on something else to follow. Bearing in mind what are the evil tendencies to be encountered in school discipline—want of application being the most constant—we may review the different kinds of penalties that have been placed at the disposal of the schoolmaster. The occasional aggravation of disorder and rebelliousness has also to be encountered, but with an eye to the main requisite.

Simple forms of disgrace have been invented, in the shape of shameful positions and humiliating isolation. As appealing to the sense of shame, these are powerful with many, but not with all: their power varies with the view taken of them by the collective body, as well as with individual sensitiveness. They answer for smaller offenses, but not for the greatest; they may do to begin with, but they rapidly lose power by repetition. It is a rule in punishment to try slight penalties at first; with the better natures the mere idea of punishment is enough; severity is entirely unnecessary. It is a coarse and blundering system that knows of nothing but the severe and degrading sorts.

Detention from play, or keeping-in after hours, is very galling to the young; and it ought to suffice for even serious offenses; especially for riotous and unruly tendencies, for which it has all the merits of "characteristicalness." The excess of activity and aggressiveness is met by withholding the ordinary legitimate outlets.

Tasks or impositions are the usual punishment of neglect of lessons, and are also employed for rebelliousness; the pain lies in the intellectual *ennui*, which is severe to those that have no liking for books in any shape. They also possess the irksomeness of confinement and fatigue-drill. They may be superadded to shame, and the combination is a formidable penalty.

With all these various resources ingeniously plied—emulation, praise, censure, forms of disgrace, confinement, impositions—the necessity for corporal punishments should be nearly done away with. In any well-regulated school, where all the motives are carefully graded, through a long series of increasing privations and penalties, there should be no cases but what are sufficiently met. The presence of pupils that are not amenable to such means is a discord and anomaly; and the direct remedy would consist in removing them to some place where the lower natures are grouped together. Inequality of moral tone is as much to be deprecated in a class as inequality of intellectual advancement. There should be reformatories, or special institutions, for those that cannot be governed like the majority.

Where corporal punishment is kept up, it should be at the far end of the list of penalties; its slightest application should be accounted the worst disgrace, and should be accompanied with stigmatizing forms. It should be regarded as a deep injury to the person that inflicts it, and to those that have to witness it—as the height of shame and infamy. It ought not to be repeated with the same pupil; if two or three applications are not enough, removal is the proper course.

The misfortune is, that in the national schools the worst and most neglected natures have to be introduced; yet they should not brutalize a whole school. Even when children are habituated to blows at home, it does not follow that these are necessary at school; parents are often unskillful, as well as hampered in all their circumstances, and emergencies are pressing; the treatment at school may easily rise above the conduct of the family. In many instances the school will be a welcome haven to the children of troubled homes, and lead to the generous response of good behavior.

In point of fact, however, the children of wretchedness are not always those that give trouble, nor is it the schools where these are found that are most given to corporal punishments. The schoolmaster's most wayward subjects come often from good families; and they are found in schools of the highest grade. There should be no difficulty in sending away from superior schools all such as could not be disciplined without the degradation of flogging.[1]

[1] Testimonials are adduced from very distinguished men, to the effect that without flogging they would have done nothing. Melanchthon, Johnson, Goldsmith, are all quoted for a sentiment of this kind. We must, however, interpret the fact on a wider basis. There was no intermediate course in those days between spoiling and corporal punishment: he that spared the rod hated the child. Many ways can now be found of spurring young and capable minds to application; and corporal punishment would take an inferior position in the mere point of efficiency.

It is not to be held that corporal punishment, to such extent as is permissible, is the severest form of punishment that may be administered in connection with the school. For mere pain, a whipping would often be chosen in preference to the intolerable irksomeness of confinement during play or after hours, and of impositions in the way of drill-tasks; while the language of censure may be so cutting as to be far worse than blows.

THE DISCIPLINE OF CONSEQUENCES.—The idea of Rousseau that children, instead of being punished, should be left to the natural consequences of their disobedience, has much plausibility, and is taken up at the present day by educationists. Mr. Spencer has dwelt upon it with great emphasis.

One obvious limitation to the principle is, that the results may be too serious to be used for discipline: children have to be protected from the consequences of many of their acts.

What is intended is, to free parents and others from the odium of being the authors of pain, and to throw this upon impersonal agencies, toward whom the child can entertain no resentment. But, before counting on that result, two things are to be weighed. For one, the child may soon be able to see through the device, and to be aware that after all the pain is brought about by virtue of a well-laid scheme for the purpose: as when the unpunctual child is left behind. The other remark is that, the personifying or anthropomorphic tendency being at its greatest in early years, every natural evil is laid to the door of a person known or unknown. The habit of looking at the laws of Nature, in their crushing application, as cold, passionless, purposeless, is a very late and difficult acquirement, one of the triumphs of science or philosophy: we begin by resenting everything that does us harm, and are but too ready to look round for an actual person to bear the brunt of our wrath.

A further difficulty is the want of foresight and foreknowledge in children: they are unable to realize consequences when the evil impulse is upon them. This, of course, decreases by time; and, according as the sense of consequences is strengthened, these become more adequate as a check to misconduct. It is then indifferent whether they are natural or ordained.

Among the natural consequences that are relied on as correctives of misbehavior in the family are such as these: going with shabby clothes, from having spoiled a new suit; getting no new toys to replace those that are destroyed. The case of one child having to make reparation to another for things destroyed is more an example of Bentham's "characteristical" punishment.

In school, the discipline of consequences comes in under the arrangements of the school for assigning each one's merit on an impersonal plan, the temper or disposition of the master being nowhere apparent. The regulations being fixed and understood, non-compliance punishes itself.—*Author's advance-sheets.*

What is maintained is that these other punishments are not so liable to abuse, nor so brutalizing to all concerned, as bodily inflictions.

EXPLOSIONS FROM COMBUSTIBLE DUST.[1]

By Professor L. W. PECK.

I WISH to demonstrate to you this evening, by a few simple experiments, the fact that all combustible material when finely divided, forming a dust or powder, will, under proper conditions, burn with explosive rapidity.

If a large log of wood were ignited it might burn a week before being entirely consumed; split it up into cord-wood, and pile it up loosely, and it would burn in a couple of hours; again, split it into kindling-wood, pile loosely as before, and perhaps it would burn in less than an hour; cut it up into shavings and allow a strong wind to throw them into the air, or in any way keep the chips comparatively well separated from each other, and it might be entirely consumed in two or three minutes; or, finally, grind it up into a fine dust or powder, blow it in such a manner that every particle is surrounded by air, and it would burn in less than a second.

Perhaps you have noticed that shavings and fine kindlings will sometimes ignite so quickly in a stove that the covers will be slightly raised, the door forced open, or perhaps small flames will shoot out through the front damper. You have, in such a case, an explosion on a very small scale similar to that of the Washburn, Diamond, and Humboldt Mills of this city, on the night of May 2d—upon which occasion the rapid burning of hundreds of tons of flour, bran, etc., completely demolished the solid-masonry walls, six feet thick, of the mills, and threw sheets of iron from the roof of the Washburn so high into the air that they were carried two miles by the wind before striking the ground.

Let us see now why such explosions occur. Wood has in it a large amount of carbon, the material of which charcoal is composed, and the air is about one-fifth oxygen. Now, at the ordinary temperature, the carbon of the wood and the oxygen of the air do not combine; but, when they are heated, as by friction, concentration of the sun's rays, chemical action as from a match, or in any other way, they combine to form carbonic-acid gas. This chemical action produces a large additional amount of heat which keeps up the action as long as there is any carbon and oxygen left to unite, and also makes the temperature of the gas which is formed very high.

As the space occupied by the carbonic-acid gas and that occupied by the oxygen which entered into the combination is the same at the same temperature, there would be no bursting if, after combination, the

[1] Lecture delivered June 1, 1878, at Association Hall, Minneapolis, Minnesota, at the request of the millers of the city.

temperature were the same as before; but it is a fact, which you have all observed, that fuel in burning produces heat; it is also a fact that heat expands a gas, and it is this great amount of heat, taken up by the carbonic acid formed, that produces the immense pressure in all directions.

Let us return to our log of wood. There is exactly the same amount of heat and carbonic acid produced when complete combustion takes place in each of the cases of burning, the only difference being as to time. In the first case, the explosion or pushing aside of the surrounding air occupies a week, in the last only a second.

Snow-flakes fall gently upon your shoulders, and you are required to perform an insensible amount of work to resist the crushing effect of each flake; but, suppose that all the snow that has fallen upon your head and shoulders for the last ten years was welded together in one solid mass of ice, weighing perhaps one hundred pounds, and that it should descend with the velocity of a snow-flake upon you, an immense effort would be required to prevent its crushing you, even if you were able to withstand the shock at all. The work of many days would be concentrated into an instant.

So it is with burning wood: four or five cords of wood, and a large stove, will give you a roaring fire all winter; the work done is manifested by the heat obtained, by the rushing of hot gases up the chimney, and of air from outside into the room through every crack. But, if the wood were ground into a powder and scattered through all the house, and burned instantly, the cracks, doors, windows, and flues, would not be sufficient to give vent to the hot gas, and the roof and sides of the house would be blown to pieces.

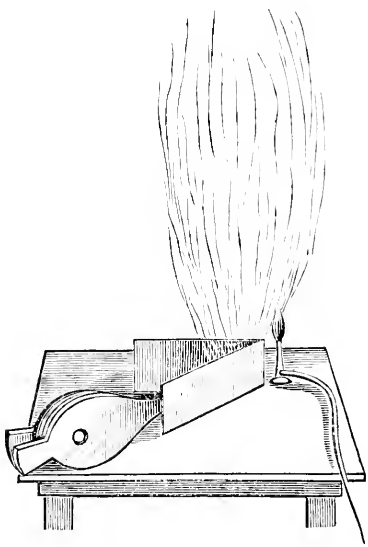


Fig. 1.

What is true of wood is also true of grains; also of vegetables, with their products when they contain carbon, with this exception: grain, either whole or ground, will not burn readily when in bulk. A fire could be built upon a binful of flour, and kept burning for half a day without igniting the flour; it would char upon the surface, but it lies in such a compact mass that the air does not get access to it readily, hence it does not burn.

I wish to show you now how combustible dust will burn when blown into the air by means of a pair of ordinary hand-bellows.

I have here two boards, about twelve by eighteen inches, nailed together, forming a V (*see* Fig. 1). Just outside of the V an ordinary Bunsen's gas-burner is placed, and within is a small handful of dust taken from a sash-and-blind factory. Upon blowing it smartly with the bellows a cloud is formed about fifteen feet high—extending, in fact, to the ceiling—which ignites from the lamp and produces a flash, very quick and exceedingly *hot*, resembling very much a gunpowder-flash. You will notice that a large amount of dust falls from all around the edge of the flame without burning; that is because it is not thick enough. Two things are necessary: first, that each grain of dust be surrounded with air, so that it can get the oxygen required *instantly;* and, secondly, that each grain shall be so near its neighbor that the flame will bridge over the space and pass the fire from particle to particle.

I think, after seeing the immense flame produced by such a small amount of fine saw and sand-paper dust, you will no longer wonder at the rapid spread of flames in furniture and similar factories. You know it is practically impossible to put out a fire after any headway is attained in these establishments; the draught produced will blow all the dust from walls and rafters into the air, and the building in an instant is a mass of flame. Perhaps many of you remember the fire in the East-Side Saw-Mills, a few years ago. Large masses of fine sawdust had probably collected upon the rafters, and the whole roof was perhaps filled with cobwebs loaded down with dust. A fire started from one of the torches used and shot through the mills with lightning-like rapidity, and, save for the fact that the ends and sides of the building were all open, there would have followed an explosion like that at the flour-mills. As it was, the men had very great difficulty in escaping with their lives, notwithstanding that a short run in any direction would have taken them out of the mill.

It is very evident that too great care cannot be taken to keep all such factories and mills as free from dust as possible.

I will now blow some ordinary starch into the air in the same way, and you notice the flame is more vivid than in the last experiment, and, if you were in my position, you would notice that the heat produced is much greater. Notice now that this powdered sugar burns in the same way.

You will see from the experiments further on that three-quarters of an ounce of starch will throw a box, weighing six pounds, easily twenty feet into the air, and that half an ounce, burned in a box, will throw up the cover three inches with a heavy man standing upon it.

With these facts, which I have demonstrated before you, no one need regard as a mystery the Barclay Street explosion in New York city, where a candy-manufactory, in which large amounts of starch and sugar might in many ways be thrown into the air by minor disturbances, took fire and completely wrecked a building and destroyed many lives.

I will now burn in the same way some buckwheat, which, as you will observe, gives a very large blaze; now some corn-meal, which is too coarse to burn as well; now some rye-flour, which burns much bet-

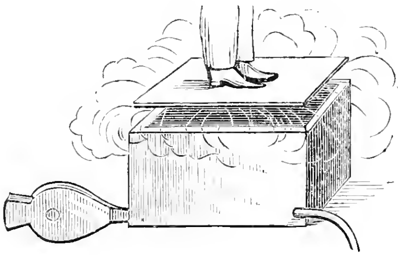


Fig. 2.

ter than the corn; now some oatmeal, the finer part of which only burns; and so I might continue with all sorts of finely-ground vegetable material.

Let us take up now the products of the manufacture of flour from wheat. There were between three and four hundred tons of these materials, upon which I am now to experiment, in the Washburn Mill at the time of explosion, and there was a corresponding amount in the Diamond and Humboldt Mills, which, by their sudden burning, produced the second and third shocks heard directly following the explosion of the larger mill.

The wheat is first placed in a machine where it is rattled violently and brushed. At the same time a strong draught of air passes through it, taking up all the fine dust, straw, etc., and conveying it through a spout to a room known as the wheat-dust room, or perhaps more commonly it is blown directly out of the mill.

You see some of this material here; it looks like the wood-dust of the first experiment, and, as you see, burns with a quick and sudden flash when subjected to the same conditions.

Here, then, we have the first source of danger in a flour-mill. A thick cloud of this dust, when conveyed through a spout by air, will burn in an instant if it takes fire; and, if there is any considerable amount of dust, as there would be if there were a dust-room, an explosion will follow which may become general if it stirs up a thick dust-cloud throughout the mill.

The wheat after it has been cleaned in this way goes to the crushers, which are plain or fluted iron or porcelain rollers, working like the rollers in a rolling-mill. The object of these rollers is, I believe, to break off the bran in as large pieces as possible, and to crush out or flatten the germ so that it can be separated with the bran from the rest of the meal.

The crushed wheat goes now to the stones, where so much heat is produced (average 135° Fahr.) that a large amount of steam is formed

from the moisture in the materials. This steam would condense in the meal and interfere with bolting, etc., if it were not removed. To effect this another draught of air and another spout are employed, and, as might be expected, this current takes a large quantity of the very finest flour, called flour-dust, with it. To save this a room is provided near the end of the spout, called the flour-dust house. The spout conveying steam and dust enters this room on one side, and another spout opposite leaves it, passing to the open air. It is in this comparatively dead-air space that the dust settles, and can be collected from the floor. Here is some of this material, which, as you see, when blown into the air, produces a vivid flash, extending from the table to the wall.

The evidence taken before the coroner's jury shows very clearly that it was this material that started the great explosion of May 2d. Just how the mill took fire will probably never be known of course, but in all probability the stones either ran dry—that is, were without any meal between them—or some foreign substance, such as a nail, was in the feed, producing a train of sparks such as is produced by an emery-wheel, or a scissors-grinder's wheel. These sparks set fire to small wads of very hot dust, which, as soon as they were fanned into a blaze, communicated it to the spout and house full of dust. An eye-witness of the explosion first saw fire issuing from the corner of the mill where this flour-dust spout was situated, the end of the spout having probably been blown out. This fire was followed instantly by a quick flash, seen through all the windows of the floor upon which the flour-dust houses were situated, followed instantly by a flash in the second story, then the third, and, in rapid succession, fourth, fifth, and sixth stories; then followed the great report produced when the immense stone walls were thrown out in all four directions, and the roof and part of the interior of the mill shot into the air like a rocket.

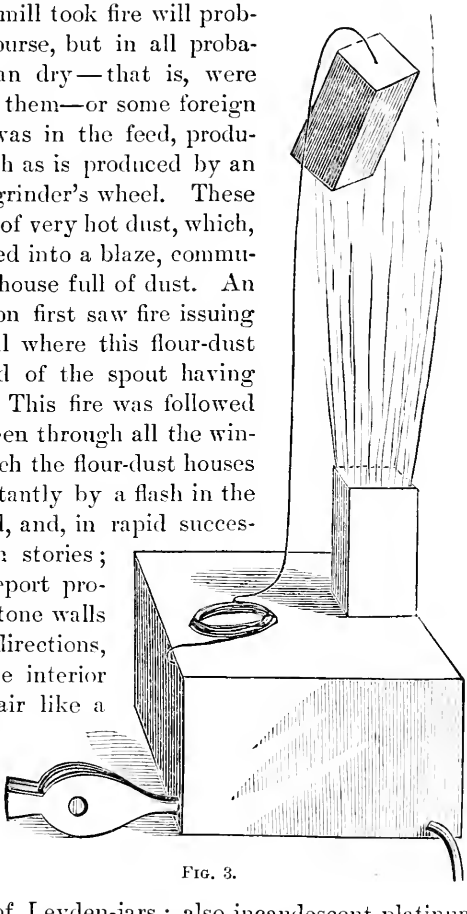


Fig. 3.

It would seem that a blaze is necessary to ignite the mixture, for I have tried powerful electric sparks from a machine, and from a battery of Leyden-jars; also incandescent platinum wire in a galvanic circuit, and glowing charcoal, without producing any fire, however thick the dust might be. Perhaps, however, under

more favorable conditions the dust would ignite directly from sparks, but it seems very improbable.

Let us continue now with the process through which the ground wheat is made to pass. From the stones it is conveyed to the bolting-reels, where the very finest is sifted out first, and we obtain a grade of flour; after the finer material is sifted out it goes to a coarser bolt, where the "middlings," as it is called, passes through, leaving the bran which comes out at the end of the reel. The middlings, as it comes from the bolts, has fine bran and dust in it, and, to purify it, it is subjected to an operation similar to that of cleaning the wheat, that is, in the middlings purifiers it is subjected to a draught of air which takes away all the light bran and dust, leaving the heavier material (purified middlings), which goes again to the stones to be ground into flour.

Here is some of the dust from these "middlings-machines;" you observe it burns as the other materials burned, quickly, and with intense heat.

Here is some of the purified middlings; each grain is comparatively large and heavy, making it difficult to blow it well into the air, but, as the blaze produced by each particle is quite large, a flash is produced which does not differ materially from the others.

Here is some of the general dust of the mill, that is, dust swept up from the floors, walls, beams, etc. You will see it acts in all respects like the other substances.

And, finally, here is some of the flour taken this afternoon from the flour-sack at home; it burns, you observe, if possible with even more energy than the other kinds of dust.

I have performed a few experiments, which I will now repeat, which will illustrate to you the immense power that these materials exert when burned in a confined space.

This box (Fig. 2) has a capacity of two cubic feet; the cover has a strip three inches deep nailed around it, so that it telescopes into the box; there is in this lower corner an opening for the nozzle of the bellows, in this an opening for the tube to the lamp. I place now a little flour in the corner, light the lamp, and my assistant places the cover upon the box and steps upon it. Take notice that upon blowing through the hole, and filling the box with a cloud of flour, the cover comes up suddenly, man and all, until the hot gas gets a vent, and a stream of fire shoots out in all directions.

Here is a box (Fig. 3) of three cubic feet capacity, including this spout, nine inches square and fifteen inches long, coming from the top of it; at the ends doors are arranged closed like steam-boiler man-holes; openings for light and bellows are arranged as in the previous box.

Here is a box, weighing six pounds, that will just slip over the spout; it has a rope lest it should strike the wall after the explosion.

Placing now the lamp in the box, some dust in the corner, and the box over the spout, we are ready for another explosion. You observe, after blowing vigorously for a second or two, the dust in the box takes fire; the box over the spout is shot off, and rises until the rope (about twelve feet long) jerks it back; it strikes the stage with great force, rebounds and clears the foot-lights, and would strike the floor below were it not for the rope.

I have thrown a box similar to this in the open air twenty feet high, while, as we shall see presently, less than an ounce of flour is being consumed.

I have fastened over the top of the spout five thicknesses of newspaper; upon igniting a boxful of dust as before, the paper is thrown violently into the air, accompanied by a loud report as it bursts.

For the last experiment I have a box of four cubic feet capacity (Fig. 4); five sides are one and a half inch thick, the remaining side one-quarter inch. Upon igniting the dust in this box, filled as in the other cases, the quarter-inch side bursts, and a stream of fire shoots out half-way across the stage.

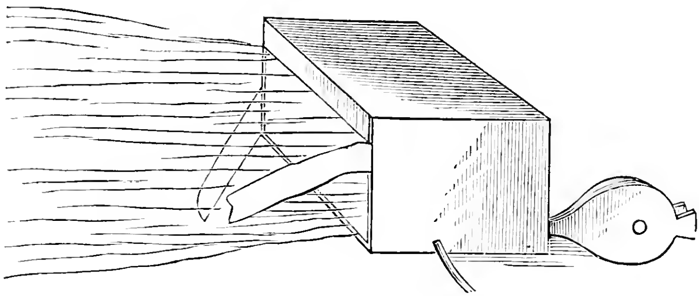


Fig. 4.

One pound of carbon and two and two-thirds pounds of oxygen, when they combine to produce carbonic acid, will evolve heat enough, if it were applied through a perfect heat-engine, to raise 562 tons ten feet high; if, therefore, forty per cent. of flour is carbon, it would require two and a half pounds to accomplish this result, if an engine from which there would be absolutely no radiation, conduction, or loss of heat, in any way, were a practical possibility. Let us see how much air would be required to supply oxygen enough. Under ordinary conditions every 100 cubic inches of air contains 7.13 grains of oxygen, from which we find that $151\frac{1}{2}$ cubic feet of air would be required for the $2\frac{2}{3}$ pounds of oxygen. Hence the $2\frac{1}{2}$ pounds of flour must be equally distributed as a dust through $151\frac{1}{2}$ cubic feet of air, in order to produce the most powerful result.

If 41 ounces of flour requires 151 cubic feet of air for perfect combustion, one cubic foot of air will supply oxygen enough for $\frac{40}{151}$ of an ounce of flour. Hence our box, which lifts the man so readily, burns

one-half ounce of flour or less; and the other, which throws the box into the air, three-quarters of an ounce, unless, as I think quite probable, an additional amount of air is drawn in through the cracks as soon as the vent is opened at the top of the box. In fact, these experiments work better if a few small holes are made near the bottom of the boxes.

It may be worthy of mention here, as a point of interest to insurance companies that, in all dust-explosions, a fire precedes the explosion in every case. The dust must burn before the heat that produces the immense expansive force is generated.

Too great precaution cannot be taken in all kinds of manufactories, where combustible dust is produced, against fire, especially in those establishments where it is conveyed in thick clouds by air-draughts through spouts and rooms.

PROFESSOR HUXLEY BEFORE THE ENGLISH COPYRIGHT COMMISSION.[1]

CHAIRMAN. Your attention has, no doubt, been called to the copyright question in a practical shape?

Answer. Yes.

Q. Will you kindly give the commission a general outline of the way in which it presents itself to you?

A. It appears to me, in the first place, that, if there be any foundation for property at all, it is as clear in the case of a book as of anything else, a book being the investment of a man's capacity and knowledge, and requiring the sacrifice of a vast amount of his time. Under those circumstances it appears to me that *prima facie* it has the same right to be protected as any other kind of property. But then, of course, a practical difficulty arises from the fact that a book can be readily copied, and that under those circumstances what evidently amounts to stealing the property of the author cannot very well be brought under the ordinary conditions of theft. I should, however, be glad in the first place to express my belief that, so far as a matter of right is concerned, if there be any foundation for rights of property, the right of an author in a book is as complete, and extends as far, as the right of any person to any property whatever. I think that my view upon the subject will be clear if I take the concrete case of a man who has written a book and who has a certain number of printed

[1] Friday, April 13, 1877: Lord John Manners, M. P., in the chair. Members of the commission present, Sir Henry T. Holland, Sir John Rose, Sir H. Drummond Wolff, Edward Jenkins, Esq., M. P., Dr. William Smith, James Anthony Froude, Esq., Anthony Trollope, Esq.

copies of it in his printer's or publisher's hands. I presume that there is no doubt whatever that those copies are his property in the strictest sense of the word, and that the law will protect him against any person who proposes to rob him of that property. I have recently met with the argument (and, singularly enough, professing to proceed from the straitest school of free-traders), that the state, or the Legislature acting for it, should, as I understand the argument, regard books as a kind of property to be disposed of mainly for the benefit of the persons who read them, and that the state should take upon itself somewhat the same function as it used formerly to do when it passed sumptuary laws, and should regulate the amount of profit to be derived by the author according to what it considers fair and reasonable. That strikes me as being a reversal of all rules of commercial policy at present recognized. But supposing it to be admitted that that is a right and just thing to do, I do not see why you should not go a step further. If, for example, I had had the good fortune to write such a work as "Hamlet" or the "Principia," it would appear, according to that line of argument, that the state would be justified in seizing all the copies of it, and in disposing of them in such a manner as might be conducive to their distribution, and that mainly on the ground of the great service to the public which those books might render. I do not know whether any one has carried the argument so far as that, but it appears to me to be the legitimate outcome of it. However, an author who has an edition in his publisher's hands has a right, at present, to regard it as his absolute property, to deal with as he pleases, and he has a further right as vender to make any contract which he pleases with any person who proposes to be a purchaser of one of the copies of that book; that is to say, if he chooses to make it a condition of sale that the purchaser shall not copy or multiply by printing the work which the vender sells under certain penalties, I apprehend that the existing law will enable him to recover those penalties from any person who violates that contract. The property being his own, he has a right to make any conditions he pleases with regard to the disposal of it; the person who buys buys on those conditions, and is subject to them. That appears to me to be the natural mode of looking at the trade in books as a branch of commerce which is subject to the ordinary rules of free trade, namely, that a man shall make any contract which he pleases with regard to the disposal of his property. And I look upon the copyright law simply as a means of overcoming the inconvenience which would arise out of that state of things; it would be a very cumbrous process; it would largely interfere with the sale of books, and it would doubtless be very hard to recover the penalties in the case of a breach of contract. So far from copyright law being any favor which the state confers upon the author, any privilege which is granted to him by the state, it seems to me that it is simply a mode of preventing such inconvenience as I have just referred to; so that in my

apprehension the application of the word "monopoly" to persons who possess rights under the copyright law is an entire mistake; it is merely a contrivance, arising out of the peculiar nature of book property, to put that property upon the same footing as other kinds of property. I think that that is all I have to say upon the general part of the question.

Q. Are we to understand it to be your contention that, under the old common law of the country, there would have been a right in the author to sell or not to sell his book in any way he pleased, and that for the convenience of the public the statute law has intervened, and, by what is commonly called the law of copyright, has attached certain conditions, and even restrictions, to that common-law right, for the benefit of the author on the one hand and of the public on the other; is that generally your view?

A. I would not suggest for a moment that that is the actual historical origin of copyright law, but I think that that is the way in which it ought to be regarded as a matter of equity.

Mr. Trollope. Those who have given evidence before us rather in opposition to than in support of the present law of copyright have sometimes done so on the plea that the law at present is favorable rather to booksellers than to authors, and they have based that plea on an idea that authors, as a rule, dispose of their copyrights to publishers, so that the property becomes not the property of the man who has worked with his brain, but merely of a speculator. As far as you are aware, do you think that authors do dispose of their copyrights entirely?

A. I cannot say. I certainly do not do so myself, and I do not think that I know among the men of science anybody who does; but it appears to me that, supposing such to be the case, it applies to all sorts of property, and to the relations of needy men to middle-men of all kinds.

Q. The second part of your answer is perhaps a sufficient answer to the next question which I was going to ask you. As far as you are aware it is not so; but, even if it were so, you do not think that that would be any argument against the present law of copyright?

A. No; I take it that that must inevitably happen wherever men want money, and there are persons who are willing to buy their property.

Q. It has been suggested to us, though I can hardly say that it has been absolutely recommended, that, in lieu of the present modes of disposing of literary property, an author should have a right to a continued royalty; that is to say, that any publisher should be enabled to bring out an author's work, paying him some proportion of the price, which should be fixed not at all by the author, but by the law. Do you imagine that such a scheme as that could work?

A. No. Who is to be the judge as to what is the value of the author's work but himself? Who is there in the Government who is

competent to form the slightest conception about it? What suggests itself to me is that the matter should be left to the ordinary operations of supply and demand. Why am I to be debarred from making any bargain I please with regard to a piece of literary property, otherwise than with regard to any other property?

Q. Does not it occur to you that no fixed percentage, let it range as it might, from five up to fifty per cent., could be fairly applicable to all classes of books?

A. Am I to understand that the proposition is to make one fixed percentage for all classes of books?

Q. As far as we have understood the proposition that is the proposition which has been made.

A. I can hardly conceive that that has been made as a serious proposition by anybody who knows anything about the writing of books; it is simply astonishing.

Q. You are aware of the present term of copyright?

A. Yes.

Q. You are aware that the copyright for your works will probably not come to an end all at the same period, unless it should happen that you should live for a very long time after the completion of the last; for instance, that if you were to die say within the next fifteen, twenty, or thirty years, the copyright of your works would come to a close at various periods, the law being that each should have whichever was longest, forty-two years or seven years after life; and you may probably be aware, to take the instance of one author, that the earliest of Mr. Dickens's copyrights are running out, I believe, in this year, and that the latter of them will run on to, I think, the year 1912. Does it not occur to you that it would be desirable that property of this kind should come to its conclusion all at one and the same time?

A. Your question rather involves an opinion upon the propriety of terminating the copyright at all, and I am by no means satisfied that there is any ground for terminating a man's right to his property in books rather than in anything else.

Q. You are probably aware that the French term is fifty years after death, and the German thirty years after death?

A. Yes.

Q. And that therefore in Germany or in France the copyrights of an author will come to their conclusion at the same time?

A. Yes.

Q. I will ask you whether you do not think that that mode is a better mode than the one which we have adopted. Putting aside the question whether an author's copyright should be perpetual, and assuming that the law will enact as it has enacted, that there shall be a term, would it not appear to you that a term similar to the French or the German term would be better than ours?

A. I think so, if you are to have a limit.

Q. You will no doubt perceive, with regard to your own works, that under the present system a time will come when your executors, or those who come after you, will be debarred from protection in the publication of all your works, although they will be protected in the publication of a part?

A. Certainly.

Q. Does not that appear to you to be inconvenient?

A. I think so, very.

Mr. Jenkins. You say that you think that a book, being the investment of a man's capacity and knowledge and time, is as much his property as any other property, and that the right of an author extends as far as the right of any person to any property whatever. I only want to ask you to point out what, of course, must have occurred to you, that there is a distinction between a book which conveys ideas and a machine which embodies them in a form which cannot be carried away or altered; and I would ask, considering the fact that supposing you write a book, another man, without stealing your book can steal all your ideas, and adapt and use them, whether there is not, therefore, a distinction between the property in a book and the property in any other thing?

A. No; I do not think that the property in a man's book consists in the ideas. I should limit his property entirely to the particular form in which he chooses to clothe those ideas. If you come to look into the matter carefully, it would be very hard to say how far the ideas contained in a man's book are his own; he owes them very largely to his ancestors and his surroundings, and to other people, and I do not think that it is at all clear that you would be justified in laying an embargo upon a particular set of ideas because they happened to be contained in a particular book. My contention for the protection of property in books is entirely with regard to the particular form in which the author chooses to put his ideas.

Q. Supposing that, instead of writing a book, a man gives a series of lectures, for instance, as you do—fortunately for England—and that those lectures are reported, or that persons carry away in their memory the words and the essence of them, you admit that then, a man having chosen to disperse them to the world, neither on principle nor upon the grounds of expediency ought it to be held that those lectures are to be reserved for the man himself?

A. Certainly not the ideas or the facts; but I take it that a man has no right to publish a report of what he shall call my lecture; that is quite another thing: then he asserts that the form is mine as well as the substance. If he chooses to appropriate my ideas and himself publish them in any other form, and say, "This is what I think," I do not think that he should be prevented from doing so, and in my opinion he has a right to do it; but it is quite another matter if he calls anything which he chooses to publish my lecture.

Q. Take the case of Fichte: when he was twelve years of age, if he heard a sermon or an address he could go away and repeat it verbally; you cannot prevent that?

A. Certainly not.

Q. He carries away the ideas, and carries away the whole thing: is he to be prevented from transferring it to anybody else?

A. He is to be prevented from putting it in the shape of a book, and selling it to the disadvantage of the person who has given the lecture or the sermon.

Q. Are you laying down a question of abstract principle, or is it merely one of expediency?

A. With regard to that particular case of lectures, it is a point on which I hold a very strong opinion indeed. I have seen the opinion advanced that a man who has given a lecture has given it to the world, in the same way that a man who has written or published a book has given it to the world, and that on the ground of his having given it to the world he cannot call it back again. I must confess that that strikes me as the strangest confusion between publication and donation. If I announce myself as ready to give a lecture to-morrow, to which persons may be admitted at a certain fee, I make a contract with the persons who come that, in consideration of their paying so much, they shall hear me speak for an hour, and that is all; I do not sell my right to print it and sell the lecture, and especially not my right to call it mine; the contract is a perfectly clear one. Take the case that I open a gallery of photographs, and that I say that people shall be admitted on paying a shilling each: I do not give to every person who comes there the right to copy my photographs and sell those copies himself; we see at once that that would be a preposterous supposition; and in the same way a person, who is admitted to my lecture on the understanding that he is to get his money's worth (if it be his money's worth, I do not say that it will be) in hearing me speak for an hour, does not thereby obtain the privilege of making a profit by printing it and calling it my lecture.

Q. But you admit that, even if you give a lecture to a limited audience, your ideas are thereby distributed?

A. I do not ask for any protection to ideas; it is the form of the thing which is mine.

Q. It is simply the matter of the form in which you embody your ideas, and it is for that that you claim protection?

A. Certainly.

Q. Is there not a very great distinction between the form literary and the form artistic or mechanical?

A. I really do not see where the distinction lies.

Q. Supposing that I have invented a machine, if I write an account of it to the *Contemporary Review* or the *Forntightly*, or to any mechanical magazine, and it is published, after that I cannot get a patent for it?

A. No.

Q. Why, therefore, should you who have given a lecture, or have even written a lecture, if you choose to make it known in any way to other persons, have a right still to get a copyright for it?

A. The assumption in that argument, I think, is that the patent law is just; to that I venture to demur, in which case I need not follow out the parallel.

Q. I am advisedly not putting a question about the justice of it?

A. It is obvious that, if I do not admit the justice of a regulation in virtue of which a man who has published a design for a machine cannot obtain a patent for it, the rest of the argument does not affect me.

Q. Then you would put them all on the same footing?

A. Certainly.

Q. So that, really, to support the whole of your argument, you would be obliged to fall back upon this: that a man has a copyright in his ideas?

A. No; in the form into which he puts them. For example, in the case which you were suggesting to me just now, a man who makes a machine not only has an idea about his machine, but he embodies it in a particular form, with a certain application; and I think that is one of the great defects of the present patent law, that it has given protection to the idea in applications of which the original inventor never dreamed. I should restrict all protection of that kind to the precise result of a man's intellectual activity, that which is specially his own.

Q. Before we had a copyright law it was held, as you are probably aware, that if a man had embodied his ideas in the shape of a manuscript, that manuscript before he had handed it to a printer was his property, not merely the paper and the writing, but also all that was in it, that is to say, the form in which it was embodied, and that he could sell it to a publisher; but now there is an alteration in that: before a man hands his manuscript to a publisher he has a right to the ideas and to the form, but, after he has handed it to a publisher, and it is published, then in virtue of the statute law he becomes entitled to a property in what you very properly call the form of the book. The result, after all, is that it has simply been adopted as a matter of expediency and of public policy that there should be conferred upon men who write books a certain right of obtaining a profit from them during a certain time. If your contention were correct with regard to the theory of a property in books and ideas, ought not the property to be a lasting one without any definite period?

A. Certainly; I have not a doubt of it.

Q. Then you would urge upon this commission that, when a man had put his ideas into the form of a book, the copyright in that book ought to exist forever?

A. I think that, as a matter of strict right, it should be so, but as a matter of expediency I do not think it is worth while asking for it; I

think that a couple of generations would probably be as much as in practice is really needed; but, if you ask me what I think is his abstract right, I should certainly say that the man should have the property in perpetuity, and be able to hand it down to his children like any other property.

Q. Then on what theory is our present copyright law framed, if that is your opinion?

A. I would rather decline to have to justify the existing copyright law at all; I am not concerned in doing so; I think that it is not easily justifiable.

Q. That brings us to a practical question: how would you practically embody in legislation your idea of the principles of a just copyright law.

A. That would really be a matter requiring very grave consideration.

Q. Let us take it in stages. First of all, at all events, you would insist upon the absolute right of the author to a property in his book?

A. Yes.

Q. In perpetuity?

A. I do not insist upon perpetuity.

Q. I mean simply for the moment, abstractedly?

A. For the present.

Q. Then you would recognize that there might be reasons of public policy why it should not be granted in perpetuity?

A. I would rather say that it is not worth while practically to attempt to get a thing which it is hardly likely you will be able to get under the present state of the public feeling. If we had to begin *de novo*, I should certainly insist upon the perpetuity of the property, but at present I think that it would be impracticable and hardly worth while.

Q. Still, going upon your principle that, abstractedly, the author ought to have it in perpetuity, of course it would only be a reservation on the ground of public policy, or something of that sort, which would justify a limitation?

A. I think that there is another justification, namely, that it is not worth while in real life to attempt to get things which it is impossible to get.

Q. We are really looking at the matter for the moment from different standing-points: I am not asking you to consider it from the point of view of an author who is willing to take what he can get; I am asking you, if you will do so for the moment, to look at it simply from the point of view of a statesman who is considering what ought to be the principles of the law. First of all you lay down a very wide and general principle, namely, that an author is entitled to the ideas which he embodies in a book as much as any other person who owns property, whether it is a table or an acre of land, is entitled to it?

A. Pardon me, I have been very careful to say that I think that an author has a right to the form in which he embodies his ideas.

Q. That is what I said; I supposed him to embody his ideas in a book. Then you will admit that, if there is a copyright law which limits that right, the only justification for that limitation would be public policy, or public convenience, or something of that sort. Let us take it from that point of view: how can you reconcile that view of the principle of a copyright law with the existing law?

A. I do not reconcile it; I ventured to say just now that I think that the present law is bad in principle.

Q. Then you admit that the present law is not based on your principle?

A. Certainly not.

Sir H. D. Wolff. Have you thought upon the subject whether it would not be for the advantage of authors that the copyright should be extended for a period longer than exists at present; that it should even be made the perpetual property of the family of the author?

A. My impression is, that it would be for the advantage of the author if copyright were made perpetual.

Q. You said just now that the legislation had not given any privilege to the author by giving him copyright; surely it gives him a protection to his property which would not otherwise exist; do you not think so?

A. Quite so. But I ventured to say that that was not a boon but simply a piece of justice, and that he ought to have the protection.

Q. But do you not think that the Legislature would not give the protection unless it was for the benefit of the public that authors should be encouraged?

A. Assuming that it is advantageous that they should be encouraged, a certain benefit is given to the public.

Q. The copyright is given to the author that he should be free to publish his works?

A. I look upon a book in the same way as I look upon any other kind of property. There are people who discuss the expediency of the protection of any property at all; but it appears to me that upon every ground upon which it is expedient to protect any sort of property it is expedient to protect book property.

Q. I am not at all disputing that, but I wish to arrive at this view, that you give this protection to the author to enable him to have property in what is a peculiar property; there must be a peculiar protection given to a property of peculiar nature, and, having once given him that protection, do you not think that the book itself, or the chattel which he produces, should then go into the ordinary rules of supply and demand; that is to say, that when you have done that, and have reserved to him his property in his book, the public ought to be able to obtain

that book, so long as his rights are guarded, at the cheapest possible rate?

A. I do not see why the public has a right to demand it in the case of books more than in the case of beef, or mutton, or potatoes.

Q. Except that in the supply of beef and mutton and potatoes there is a regular competition?

A. Certainly.

Q. Whereas, there is no competition in books. If you cannot get beef you will get mutton. Whereas, if you cannot get Macaulay's "History" you will get nothing else which represents Macaulay's "History." You want that particular book?

A. But you might say that you want six-year old mutton, and that you cannot be content with anything else.

Q. We do not negotiate with foreign countries to obtain a copyright for six-year old mutton. The object of this commission is not only to improve the laws of copyright in England, but to see whether we cannot extend the rights of English authors to other countries?

A. That is a totally distinct question.

Q. We are the public practically who negotiate for you. If we do that, do you not think that we are entitled to some compensation for the trouble which we have in obtaining all these privileges for you?

A. I am not at all clear about that. I think that, in these matters, the state should have regard to public justice and public morality, without looking for any particular reward from the persons who are served.

Q. But by the present system of copyright, according to the ideas of some people, it does not merely secure the property for the author, who is clearly entitled to every advantage which the law can give him, but it enables the sale of books to be conducted on principles which are not acknowledged in any other branch of trade. For instance, it enables a bookseller or publisher to keep up books at an unnatural price for his own advantage, and, as is thought by some people, very often to the disadvantage of the author.

A. That I cannot comprehend, because in all my own dealings with publishers I have made my own terms, and, if the terms of the publisher do not suit me, I do not publish with that particular publisher.

Q. That I can understand; you make your own terms, no doubt, but some people think that, if instead of the present system of publishing books at a dear rate, and putting them through the circulating libraries at a high rate, any means were devised by which authors could go direct to the public, a larger sale of a cheaper edition of their books would give them greater popularity, as well as more money, than the present restricted system through the circulating libraries?

A. I think that it is a very dangerous thing to suppose that you can regulate matters of that kind by legislation.

Q. But supposing that we obtain copyright for you in America, where

the sale of your books is stated to be enormous, it gives you protection, and a greater remuneration for your books in America; would it not be unfair in that case that we, having done this for you, should as the British public be exposed to having a dear edition of your books here, and a cheap edition in America?

A. I would much rather that you did not interfere with us at all. I am now speaking of you as legislators. I would rather that you should not afford especial protection, but should consider books as property like any other property, and not meddle with us in future.

Q. We cannot take that course, because foreigners do interfere with you.

A. And in my opinion they will continue to interfere. I know something about the United States, and their mode of doing business in books in that country, and my own belief is that the expectation that the Americans will ever listen to any proposal of English copyright is chimerical; their system of doing business is quite opposed to it. I do not think that this prospective boon which you offer us is likely to have any great value.

Q. As a matter of author's *amour propre*, would it not be far more satisfactory to you if your books were possessed by a very great many households in this country rather than being hired from a circulating library?

A. I do not care much about it; if I have half a dozen careful readers, I would rather have them than all the rest of the world put together.

Q. If you got more pay than you do now from having your books sold at a cheaper rate, you would be satisfied with that?

A. I should like to get the more pay in my own fashion, and to deal with it like any other business. I do not want anybody else to help me to get more pay; if you let me deal with my own property in my own fashion, I am quite happy, and I do not thank anybody who interferes.

Sir H. Holland. From your knowledge of American dealing, do you think it at all probable that the Americans would be inclined to make a convention upon the understanding that the book for which copyright is granted is to be published and printed in America?

A. I have never heard that question discussed.

Chairman. Several questions have been asked upon the general aspect of copyright. Coming more to the details of the question, might I ask you what in your opinion would be the effect of the abrogation of or a considerable diminution in the terms of copyright upon works the production of which requires time and research, and perhaps costly illustrations?

A. My impression is, that it would be altogether fatal to the production of works of that kind. I think it will be obvious that such must be the case; and I can speak the more strongly here, because works of that kind are those with which I am familiar. I will take the

case of any one who has been preparing a work, let us say upon comparative anatomy, which has probably occupied him for a great many years. He has himself had to make a great number of laborious dissections and to have them drawn, and he or his publisher has had to invest a great deal of money in illustrations. He brings out his book. That book, if it is well done, will preserve its value for a century. At the present moment Cuvier's "Ossemens Fossiles," which I think has been published for about half a century, is in many respects as valuable a book as ever it was, and is as often consulted as ever it was. If, when such a book as that is published, or within a short time after it is published, anybody has a right to republish it, the practical effect is that the text will be copied, at probably a thousandth part of the expenditure and time required for its original production, then the illustrations will be copied; and the natural result will be that the reproduction of the book will be sold at a price far less than that at which the original book was sold, the consequence of which is that the author and the publisher of the latter alike have their interests ruined; and the practical result would be that no publisher would take such a book; in fact, he could not do it, he would be liable at any moment to be undersold. That is true of the whole class of botanical works, zoölogical works, anatomical works, and the great mass of illustrated works having relation to physical science.

Q. Carrying on the thought which you have expressed, what, in your opinion, would be the practical result upon all this important class of works which you have described of either abrogating or materially diminishing the term of copyright so far as the public is concerned?

A. I think that it would simply stop their production, and that exactly in proportion to their value and usefulness. The more such works were sought after, and the better they were, and the more largely they were in demand, and suited themselves to the wants of the time, the more certainly would they be pirated, and I do not see how anybody could afford to produce them.

Q. Might it not be that some publisher in a very large way of business might find that he could impose his own terms both on the author and the public?

A. I quite think that that is the inevitable tendency of the abolition or a great diminution of the term of copyright; and I would justify that belief by what happens at the present time in the United States; I myself am paid upon books which are published there; my American publisher remits me a certain percentage upon the selling price of the books there, and that without any copyright which can protect him; but then I am informed that the practice of all the great houses in America (there are some three or four large publishing-houses with very great capital), if anybody publishes one of their books, is to publish a largely cheaper edition at any cost, and they would make any pecuniary sacrifice rather than not cut out a rival. The great houses

understand that, and the consequence is that they do not play that game with one another; but, practically, English authors at the present time stand in the same relation to the American publishers that they would to the English publishers if copyright were abolished; and whether I get any money or not from America for my works is entirely dependent upon the strength of my American publisher. If he were not a man who would not stand being trifled with, and if it were not known that he was so, he could not afford to pay me anything.

Q. Therefore, in your opinion, the effect of the contemplated change would be not in the interest of the author, but in the interest of the publisher?

A. I think that neither the author nor the publisher would be served, and I think that the publisher's business would be made very precarious. He might doubtless sometimes reap large profits, but he would always be at the mercy of unscrupulous competition.

Mr. Trollope. Are you assured that this rule to which you allude among American publishing-houses always prevails?

A. I cannot say; I have been assured that it does largely prevail there.

Q. Then you would be surprised to hear if I told you that a large American publisher, who has been for many years in the habit of publishing my own books, and with whom I once remonstrated for doing so without consulting me, told me that he intended to continue to do so, but that he would not republish a certain work if it were published by any other American house before him?

A. Yes; that is a very curious fact. I know of no parallel cases.

Q. But if the case to which I have now alluded is a type of the way in which business is done in the United States, it would be subversive, so far, of the evidence which you have given, would it not?

A. Quite so; but my opinion is the exact contrary. I have been informed (I do not profess to have absolute proofs of it) on exceedingly good authority that a publisher who has published one or two of your books in the United States would think himself very hardly used if you allowed any other publisher to publish for you.

Q. I think that you will understand the point which was put in my question, which intended to convey the story of a transaction which had absolutely taken place?

A. Quite so; I quite understand that.

Q. I do not know that I need hesitate to say that the publisher was Mr. Harper, and you are aware that he is probably one of the largest publishers?

A. Yes.

Q. You also said, I think, just now incidentally, in answer to a question from Sir D. Wolff, that you were very strongly of opinion that American legislation would not give us the international copyright which we are seeking?

A. I think it exceedingly improbable. So far as I can gather the state of public opinion in America, their reply to all remonstrances is, "We want to have cheap books for our people, and we will not listen to anything which will interfere with our having cheap books for our people."

Q. You may probably be aware that a very large body of American publishers, not, I think, including the largest houses, but still including many large houses, have advocated international copyright?

A. Yes, I am aware of it.

Q. And you perhaps are aware that, although the list of those who have done so does not contain all the larger houses, it contains by far the greatest number of those with whom we are acquainted?

A. I have understood so. I was never myself quite clear how far the movement was in earnest.

Q. I think that the house with whom you are yourself concerned, that of Messrs. Appleton, agree to it, do they not?

A. I believe so.

Q. I will not mention other names, but can I have reason for supposing that they are not in earnest, considering that they have spent considerable sums of money in advocating their cause?

A. I will not venture to say that particular gentlemen who have advocated this cause are not in earnest; very possibly they are; but it does not appear to me to be compatible with the universal cry which one hears, or which is always raised, when this question is discussed, "We want cheap books for our people, and we will have them at all costs."

Q. Are you aware that the Senate in the United States at one time assented to a proposition for an international copyright?

A. I have heard so. It is a very curious thing that whenever negotiations of that kind arise they are carried on very successfully for a time, and very admirable speeches are made upon all sides, but they always come to nothing.

Q. In our own legislation at home has it not generally been the case that great changes have been ventilated for a considerable time and have failed, and failed, and failed, until at last they have been passed?

A. Yes; that I think has generally been where there has been a great popular cry in their favor. When I visited the United States the popular cry appeared to me to be just the other way; it was for getting cheap books at all costs. I should not like to give very decided opinions upon these matters, but that is what has struck me.

Dr. Smith. If I understood you aright in reference to illustrated works you said that the cost of the original drawing, and the drawing in wood, and the engraving, must be very large, and that there are processes, by means of photography and other means, by which they could be reproduced very cheaply?

A. Yes.

Q. And consequently that if the term of copyright was materially abridged, or if another publisher was allowed to reprint them by paying ten per cent. royalty, he could reprint those works at such a very much cheaper price than that of the original edition as to render it almost impossible for a person to obtain any profit from the original edition ?

A. Not only by the mere process of copying, but it stands to reason that if anybody has provided woodcuts in an extensively illustrated work, even if those woodcuts are reëxecuted in wood by the best artists, it can be done at a far less cost for a copyist than for the original publisher, because the woodcut in the original book represents not merely the labor of the wood-cutter, but the labor of an artist who has been employed before the wood-cutter to make the drawing from which the wood-cutter makes his woodcut, and in all probability many hours' labor of the person who made the dissection, or whatever it was, which is there depicted.

Chairman. Some questions, I believe, were asked you with respect to copyright in lectures ?

A. Yes.

Q. Are you aware of what the practical protection afforded to lectures by the present law is ?

A. I have understood that it is a very curious protection, and that you have, I think, to give notice to a justice of the peace.

Q. To two justices of the peace ?

A. I should like to speak very strongly upon that point, because I myself have had occasion to feel the ill effects of the present practice. I think that it is a most iniquitous thing that a man who is admitted to a lecture should be able to print it with your name to it, and circulate it through the country with all the faults and imperfections arising out of the mode of reporting, without asking your leave or without your being able to restrain him.

Q. Having expressed the grievance which you feel, are you prepared to give the commission any suggestion as to the mode of removing that grievance ?

A. I think that the simple and obvious course is to give a man absolute property in his lecture.

Q. But unless the public were informed in some way that that absolute property was given, might there not be injustice on the other side ?

A. I do not think so ; I think that the light of Nature ought to tell a man that he has no business to report a lecture and sell it without the permission of the person who gave the lecture. It does not require a very keen moral sense to see that that cannot be considered quite a right proceeding.

Q. But there are reporters and reporters. If a public lecture were given on a very interesting subject, I presume that the reporters of the

daily press would attend; would you draw a distinction in that case between them and a reporter of another sort?

A. No; I should always make it the right of the speaker to admit reporters or not. Allow me to tell you what happened to myself. I am not complaining of it for a moment, because I knew exactly what was to be expected, and I did not care whether it happened or not; but permit me to state what happened to me in the United States the other day: I gave three lectures in New York, which had cost me a very considerable amount of trouble, and they were illustrated by diagrams, etc. I found that it was the intention of the proprietor of one of the leading papers there to send short-hand writers who would take down what I said *verbatim;* to send artists who would copy all the diagrams, and to print my lecture the next day in the paper in full, and not only so, but when the three lectures were completed to make them up into a sort of pamphlet and sell it, without consulting me in any way whatever. As I say, in this particular case I did not care in the least about this proceeding; and I have the less reason for complaint, as the proprietor of the paper subsequently offered me a certain share in the profits of the sale of the pamphlet; but, in principle, it appears to me to be sheer piracy.

Q. That, of course, would be under the law of the United States. Are you able to tell us what the United States law with respect to lectures is?

A. I cannot say, but the same thing might take place here if I had not given notice to two justices of the peace, or complied with whatever is the requisite formality, which is a thing I never did in my life. I fancy that in practice the same thing might be done here.

Q. If you gave a proper notice, you would have the law on your side?

A. Very few persons know of the existence of that law.

Q. Admitting the grievance to exist, as I think the commission would probably be prepared to do, in removing it might it not be well to substitute some more easy process than that of giving notice to two magistrates within five miles?

A. Certainly, one would think that there must be a great number of easier processes than that.

Q. It has been suggested by some witness that a notice put over the door, so that everybody should see it when he entered the room in which the lecture was given, that the lecture was copyright would be sufficient; would that meet your view?

A. Yes, or the same practice might be adopted as in the case of reserving the right of translation of a book; you might put on the ticket, "All rights reserved."

Dr. Smith. Supposing that the lecturer himself gave notice, at the beginning of the lecture, that he reserved to himself the right of printing it, might not that be sufficient?

A. There might be a difficulty in proving that; but if the ticket, in addition to the other matter which was on it, had printed upon it, "All rights reserved," or something of that sort, it would be a sufficient notice.

STRANGE ANIMAL-FRIENDSHIPS.

WHY married folk, so ill-mated as to agree only to differ, should be said to lead a cat-and-dog life, is not very clear, since those household pets, being intelligent, affectionate, cheerful, and sociable creatures, very frequently contrive to live harmoniously enough together. The Aston Hall cat, that ate, associated, and slept, with a huge bloodhound, only did what innumerable cats have done. Such companionships are too common to be reckoned among strange animal-friendships, such as that most singular instance of attachment between two animals of opposite natures and habits, related to Mr. Jesse by a person on whose veracity he could depend. The narrator boasted the proprietorship of an alligator which had become so tame that it would follow him up and down stairs; while it was so fond of his cat's society that, when she lay down before the fire, the alligator followed suit, made a pillow of puss, and went off to sleep; and when awake the reptile was only happy so long as puss was somewhere near, turning morose and ill-tempered whenever she left it to its own devices.

Many equine celebrities have delighted in feline companions, following in this the example of their notable ancestor, the Godolphin Arab, between whom and a black cat an intimate friendship existed for years, a friendship that came to a touching end; for, when that famous steed died, his old companion would not leave the body, and, when it had seen it put underground, crawled slowly away to a hay-loft, and, refusing to be comforted, pined away and died.

One of Miss Braddon's heroines says: "It is so nice to see a favorite horse looking over the door of his loose-box, with a big tabby-cat sitting on the window-ledge beside him." The big tabby would probably prefer being on horseback, for puss takes very kindly to the stable, and the horse takes as kindly to puss. A cat belonging to the royal stables at Windsor made herself so agreeable to one of the horses there that, rather than put her to any inconvenience, he would take his night's rest standing. This was held detrimental to his health, and the stable authorities, unable to hit upon any other plan, banished poor pussy to a distant part of the country.

Mr. Huntington, of East Bloomfield, New York, owns a thorough-bred horse named Narragansett and a white cat. The latter was wont to pay a daily visit to Narragansett's stall, to hunt up the mice and then enjoy a quiet nap. Mr. Huntington removed to Rochester with his family, leaving the cat behind; but she complained so loudly and

so unceasingly that she was sent on to the new abode. Her first object was now to get somebody to interpret her desires. At last her master divined them, and started off with her to the barn. As soon as they were inside, the cat went to the horse's stall, made herself a bed near his head, and curled herself up contentedly. When Mr. Huntington visited the pair next morning, there was puss close to Narragansett's feet, with a family of five beside her. The horse evidently knew all about it, and that it behooved him to take heed how he moved his feet. Puss afterward would go out, leaving her little ones to the care of her friend, who would every now and then look to see how they were getting on. When these inspections took place in the mother's presence, she was not at all uneasy, although she showed the greatest fear and anxiety if any children or strangers intruded upon her privacy.

A gentleman in Sussex had a cat which showed the greatest affection for a young blackbird, which was given to her by a stable-boy for food a day or two after she had been deprived of her kittens. She tended it with the greatest care; they became inseparable companions, and no mother could show a greater fondness for her offspring than she did for the bird.

Lemmery shut up a cat and several mice together in a cage. The mice in time got to be very friendly, and plucked and nibbled at their feline friend. When any of them grew troublesome, she would gently box their ears.—A German magazine tells of a M. Hecart who placed a tame sparrow under the protection of a wild-cat. Another cat attacked the sparrow, which was at the most critical moment rescued by its protector. During the sparrow's subsequent illness its natural foe watched over it with great tenderness.—The same authority gives an instance of a cat trained, like a watch-dog, to keep guard over a yard containing a hare, and some sparrows, blackbirds, and partridges.

A pair of carriage-horses taken to water at a stone trough, then standing at one end of the Manchester Exchange, were followed by a dog who was in the habit of lying in the stall of one of them. As he gamboled on in front, the creature was suddenly attacked by a mastiff far too strong for his power of resistance, and it would have gone hard with him but for the unlooked-for intervention of his stable-companion, which, breaking loose from the man who was leading it, made for the battling dogs, and with one well-delivered kick sent the mastiff into a cooper's cellar, and then quietly returned to the trough and finished his drink. In very sensible fashion, too, did Mrs. Bland's half-Danish dog Traveler show his affection for his mistress's pet pony. The latter had been badly hurt, and, when well enough to be turned into a field, was visited there by its fair owner and regaled with carrots and other delicacies; Traveler, for his part, never failing to fetch one or two windfall apples from the garden, laying them on the grass before the pony, and hailing its enjoyment of them with the liveliest demonstrations of delight.

That such relations should exist between the horse and the dog seems natural enough; but that a horse should be hail-fellow with a hen appears too absurd to be true; yet we have Gilbert White's word for it that a horse, lacking more suitable companions, struck up a great friendship with a hen, and displayed immense gratification when she rubbed against his legs and clucked a greeting, while he moved about with the greatest caution lest he might trample on his "little, little friend."

Colonel Montagu tells of a pointer which, after being well beaten for killing a Chinese goose, was further punished by having the murdered bird tied to his neck—a penance that entailed his being constantly attended by the defunct's relict. Whether he satisfied her that he repented the cruel deed is more than we know; but, after a little while the pointer and the goose were on the best of terms, living under the same roof, feeding out of one trough, occupying the same straw bed; and, when the dog went on duty in the field, the goose filled the air with her lamentations for his absence.

A New Zealand paper says: "There is a dog at Taupo and also a young pig, and these two afford a curious example of animal sagacity and confidence in the *bona fides* of each other. These two animals live at the native *pah* on the opposite side of Tapuaeharuru, and the dog discovered some happy hunting-grounds on the other side, and informed the pig. The pig, being only two months old, informed the dog that he could not swim across the river, which at that spot debouches from the lake, but that in time he hoped to share the adventures of his canine friend. The dog settled the difficulty. He went into the river, standing up to his neck in water, and crouched down; the pig got on his back, clasping his neck with his forelegs. The dog then swam across, thus carrying his chum over. Regularly every morning the two would in this way go across and forage around Tapuaeharuru, returning to the *pah* at night; and, if the dog was ready to go home before the pig, he would wait till his friend came down to be ferried over. The truth of this story is vouched for by several who have watched the movements of the pair for some weeks past."

When Cowper cautiously introduced Puss—a hare that had never seen a spaniel—to Marquis—a spaniel that had never seen a hare—he discovered no token of fear in the one, no sign of hostility in the other, and the new acquaintances were soon in all respects sociable and friendly—a proof, the poet thought, that there was no natural antipathy between dog and hare. Upon just as good grounds the same might be inferred regarding dog and fox. We have read of a tame fox hunting with a pack of harriers; and Mr. Moffat, of Bearsley, Northumberland, owned one that was excessively fond of canine society. In consequence of detection following a raid on the poultry-yard, Master Reynard was chained up in a grass area. Whenever he caught sight of a dog coming his way, he began fanning his tail, and, laying back his ears, would

strain desperately at the full length of his tether, that he might smell at the mouth of the dog, and use all his arts to induce him to have a romp, even though he had never set eyes on that especial dog before.

In 1822 some white rats were trapped in Colonel Berkeley's stables. Mr. Samuel Moss, of Cheltenham, took a fancy to a youngster, and determined to make a pet of him. He was soon tamed, and christened Scugg. Then he was formally introduced to a rat-killing terrier, a ceremony so well understood by Flora that she not only refrained from assaulting the new-comer, but actually constituted herself his protectress, mounting guard over Scugg whenever a stranger came into the room, growling, snarling, and showing her teeth, until convinced he had no evil intentions toward her *protégé*. These two strangely-assorted friends lapped from the same saucer, played together in the garden, and, when Flora indulged in a snooze on the rug, Scugg ensconced himself snugly between her legs. He would mount the dinner-table and carry off sugar, pastry, or cheese, while Flora waited below to share in the plunder. One day a man brought Mr. Moss another white rat, while the terrier and Scugg were racing about the room. The stranger was shaken out of the trap, and presently two white rats were scampering across the floor pursued by Flora. The chase did not last long, one of them quickly falling a victim to the terrier's teeth, much to the experimentalist's alarm, as his eyes could not distinguish one rat from the other. Looking around, however, his mind was relieved, for there in his corner was Scugg, with Flora standing sentry before him—a position she held until the man and the dead rat were out of the room. When his master took a wife to himself, a new home was found for Scugg; but the poor fellow died within a month of his removal, and it is not improbable that the separation from his canine friend was the primary cause of the rat's untimely decease.

St. Pierre pronounced the mutual attachment displayed between a lion at Versailles and a dog to be one of the most touching exhibitions Nature could offer to the speculations of the philosopher. Such exhibitions are by no means rare. Captive lords of the forest and jungle have often admitted dogs to their society and lived on affectionate terms with them. Not long ago, an ailing lioness in the Dublin Zoölogical Gardens was so tormented by the rats nibbling her toes that a little terrier was introduced into the cage. His entrance elicited a sulky growl from the invalid; but, seeing the visitor toss a rat in the air and catch it with a killing snap as it came down, she at once came to the sensible conclusion that the dog's acquaintance was worth cultivating. Coaxing the terrier to her side, she folded her paw round him and took him to her breast; and there he rested every night afterward, ready to pounce upon any rat daring to disturb the slumbers of the lioness.

The last time we visited the lion-house of the Regent's Park Zoölogical Gardens, we watched with no little amusement the antics of a dog, who was evidently quite at home in a cage occupied by a tiger and

tigress. The noble pair of beasts were reclining side by side, the tiger's tail hanging over the side of their couch. The dog, unable to resist the temptation, laid hold of it with his teeth and pulled with a will; and, spite of sundry gentle remonstrances on the part of the owner of the tail, persisted until he elicited a very deep growl of disapproval. Then he let go, sprang upon the tiger's back, curled himself up, and went off to sleep. Such friendships are, it must be owned, liable to come to a tragic ending, like that recorded by an ancient writer, who tells how a lion, a dog, and a bear, lived together for a long time on the most affectionate terms, until the dog, accidentally putting the bear out of temper, had the life put out of his body; whereupon Leo, enraged at losing his favorite, set upon Bruin and made an end of him too.—*Chambers's Journal.*

THE SCIENCE OF EASY-CHAIRS.

THERE is a reason for everything, if we can only find it out; but it is sometimes very hard to discover the reasons of even the very simplest things. Every one who has traveled much, and even those who have merely looked through books of travels, must have been struck by the variety of attitudes assumed by the people of different countries. The Hindoo sits down on the ground with his knees drawn up close to his body, so that his chin will almost rest upon them; the Turk squats down cross-legged; the European sits on a chair; while the American often raises his feet to a level with his head. Nor are the postures assumed by the same people under varying circumstances less diverse. Climate or season, for example, will cause considerable alteration in the posture assumed, as was well shown by Alma-Tadema, in his pictures of the four seasons exhibited in the Academy a year ago. In his representation of "Summer," he painted a woman leaning backward on a ledge, with one leg loosely hanging down, while the other was drawn up so that the foot was on a level with the body. In the picture of "Winter," on the other hand, we saw a figure with the legs drawn up in front of the belly. The reason for these different postures has been explained by Rosenthal. The temperature of the body, as is well known, is kept up and regulated by the circulation of the blood through it, and a great proportion of the blood contained in the whole body circulates in the vessels of the intestines. Now, the intestines are only separated from the external air by the thin abdominal walls, and therefore any change of temperature in the atmosphere will readily act upon them, unless they be guarded by some additional protection. The Hindoos are well aware of this, and they habitually protect the belly by means of a thick shawl or *cummerbund*, thus guarding themselves against any sudden change of temperature. This precaution is also

frequently adopted by Europeans resident in hot climates, and is even retained by them after returning to England. But the function of the *cummerbund* may, to a certain extent, be fulfilled by change of posture alone. When the legs are drawn up, as in the picture of "Winter" already referred to, the thighs partially cover the abdomen, and, taking the place of additional clothing, aid the abdominal walls in protecting the intestines and the blood they contain from the cooling influence of the external air.

Thus it is that in cold weather, when the quantity of covering in bed is insufficient, persons naturally draw up their legs toward the abdomen, so as to retain as much heat as possible before going to sleep. In hot weather, on the contrary, they wish to expose the abdomen as much as possible to the cooling influence of the atmosphere. The posture depicted by Alma-Tadema is the most efficient for this purpose. It no doubt answers the purpose to lie down flat on one's back; but in this position the abdominal walls are more or less tight, whereas, when one of the legs is drawn up as in the painting just alluded to, the walls are relaxed, and, the intestines not being subject to any pressure, the blood in them will circulate more rapidly, and the cooling process be carried on more effectually. In this attitude also the thighs are completely separated, and loss of heat allowed from their whole surface.

Varying conditions of fatigue also alter the postures which people assume. When slightly tired one is content to sit down in an ordinary chair in the position of the letter N with the middle limb horizontal. As we get more and more fatigued we usually assume positions in which the limbs of the N become more and more oblique, the trunk leaning backward and the legs extending forward. If we lie down in bed on our back the legs will probably become straight, but if we rest upon our side they will be more or less bent. The straightness of the legs in the supine position is simply due to their weight, which is then supported at every point by the bed, but when we lie on our sides the genuflection of the legs is most agreeable, because not only are the muscles more perfectly relaxed, but, as the late Prof. Goodsir pointed out, the bones which form the knee-joint are slightly removed one from another, and thus the joint itself, as well as the muscles, passes into a state of rest. Some of the bamboo easy-chairs manufactured in India allow us to obtain the advantages of both positions. These chairs are made in the form of a somewhat irregular, straggling W, and in them one can lie on one's back with every part of the body thoroughly supported, and the knees bent in the same way as they would be if one lay upon one's side.

Thus simple inaction, the relaxation of muscles, and the laxity of joints, are some of the factors necessary for complete rest, and an easy-chair, to be perfect, must secure them all.

But it is possible for an easy-chair to secure all these, and yet be imperfect. We have just said that usually, as the fatigue becomes

greater and greater, the tendency is to assume the position of the N with the limbs at a more or less obtuse angle, but when sitting in an ordinary chair we find relief from raising the feet by means of a foot-stool, although this tends to make the angles of the N more acute instead of more obtuse. Still more relief, however, do we obtain when the legs are raised up on a level with the body by being placed upon another chair, or by being rested on the Indian bamboo seat already described. If, in addition to this, the legs are gently shampooed upward, the sensation is perfectly delightful, and the feelings of fatigue are greatly lessened. To understand how this can be, it is necessary for us to have some idea as to the cause of fatigue. Any muscular exertion can be performed for a considerable time by a man in average health, without the least feeling of fatigue, but by-and-by the muscles become weary, and do not respond to the will of their owner so readily as before ; and, if the exertion be too great, or be continued for too long a time, they will ultimately entirely refuse to perform their functions. The muscle, like a steam-engine, derives the energy which it expends in mechanical work from the combustion going on within it, and this combustion, in both cases, would come to a standstill if its waste products or ashes were not removed. It is these waste products of the muscle which, accumulating within it, cause fatigue, and ultimately paralyze it. This has been very neatly shown by Kronecker, who caused a frog's muscle, separated from the body, to contract until it entirely ceased to respond to a stimulus. He then washed out the waste products from it by means of a little salt and water, and found that its contractile power again returned, just as the power of the steam-engine would be increased by raking the ashes which were blocking up the furnace and putting out the fire. These waste products are partly removed from the muscles by the blood which flows through them, and are carried by the veins into the general circulation. There they undergo more complete combustion, and tend to keep up the temperature of the body. At the same time, however, according to Preyer, they lessen the activity of the nervous system, producing a tendency to sleep, and in this way he would, at least to some extent, explain the agreeable drowsiness which comes on after muscular exertion. It would seem, however, that the circulation of the blood is insufficient to remove all the waste products from the muscles, for we find that they are supplied with a special apparatus for this purpose. Each muscle is generally insheathed in a thin membrane, or fascia, and besides these we have thicker fasciæ insheathing whole limbs. These fasciæ act as a pumping apparatus, by which the products of waste may be removed from the muscles which they invest. They consist of two layers, with spaces between. When the muscle is at rest these layers separate and the spaces become filled with fluid derived from the muscle, and when the muscle contracts it presses the two layers of its investing sheath together, and drives out the fluid contained between them. This

passes onward into the lymphatics, where a series of valves prevents its return, and allows it only to move onward, till at last it is emptied into the ger ral circulation.

In strong and healthy people the veins and lymphatics together are quite able to take up all the fluid which the arteries have supplied to the muscles, and thus prevent any accumulation from taking place either in them or in the cellular tissue adjoining them, or at least prevent any such accumulation as might become evident to the eye. In delicate, weakly persons, or in those who suffer from certain diseases of the vascular system, this is not the case ; and after standing or walking for a long time the legs become swollen, so that the boots feel tight, and sometimes even a distinct impression may be remarked at that part of the ankle which was covered by the boot. In such persons we can actually see the swelling disappear, after the feet have been kept rested for some time on a level with the body, and it may be removed more quickly still by gently and steadily rubbing the limbs in one direction from below upward. It is almost certain that what we thus see in weakly persons occurs to a slighter extent in all, and that even in the most healthy person after a long walk a slight accumulation of fluid, laden with the products of muscular waste, occurs both in the muscles themselves and in the cellular tissue around them, even although we cannot detect it by simple inspection. So long as the limbs of such a person hang down, the force of gravity retards the return both of blood through the veins and of lymph through the fasciæ and lymphatics, and thus hinders the muscles from getting rid of those waste products which caused the fatigue. When the legs are raised, this hinderance is at once removed, both blood and lymph return more readily from the muscles, carrying with them those substances which had been formed by the muscles of the limbs during the exertions which they had undergone when carrying the body about. So long as these substances remained where they had been formed, they might cause in the muscles of the legs an undue amount of fatigue, although, when distributed over the body generally, they may produce only a pleasing languor. When the legs are long, the obstruction to the return of blood and lymph is, of course, greater than when they are short, and this return will take place more readily when the legs are raised above the body than when they are only on a level with it. This may be one of the reasons why some of our long-legged American cousins are so fond of raising their feet to a level with their heads, or even higher, although it is very probable that there are reasons still more powerful, which we may discuss at a future time.

It has already been mentioned that the lymph is propelled along the interstices of the fasciæ into the lymphatic vessels by the intermittent pressure which the muscle exerts upon them from within ; and it seems natural to suppose that the flow may also be aided by a pressure from without, in the form of shampooing. Even when the hand is rubbed

backward and forward upon the leg it will relieve fatigue, but the relief is greater when the leg is firmly grasped and the hand moved gently upward so as to drive onward as much as possible any fluid which may have accumulated in the limb, and, the grasp being then relaxed, the same process should be repeated.

But, while the lymph is thus most readily removed by the pumping action of intermittent pressure either of the hand without or of the muscles alternately contracting and relaxing within, it seems to us probable that this process may also be aided by steady, constant pressure from without. No doubt it is impossible for such a steady pressure to take the place of the regular pumping action produced by the alternate contraction and relaxation of the muscles when in action, yet it will have a somewhat similar action, though to a very much less extent. For at each beat of the heart, as Mosso shows, the entire limb is distended by the blood driven into the vessels, and during the pauses between the beats it again becomes smaller. Each pulse, therefore, by distending the whole limb and each individual muscle, will press out a little of the fluid contained in the fasciæ in the same way as the contractions of the muscles themselves; and it seems to us probable that it is the aid which is afforded to this process, by the gentle pressure exerted on the outside of the legs by a seat which supports them along their whole extent, that renders such a seat so peculiarly restful and agreeable. For an easy-chair to be perfect, therefore, it ought not only to provide for complete relaxation of the muscles, for flexion and consequent laxity of the joints, but also for the easy return of blood and lymph not merely by the posture of the limbs themselves, but by equable support and pressure against as great a surface of the limbs as possible.

Such are the theoretical demands, and it is interesting to notice how they are all fulfilled by the afore-mentioned chair in the shape of a straggling W, which the languor consequent upon a relaxing climate has taught the natives of India to make, and which is known all over the world.—*Nature.*

LANGUAGE AND THE EMOTIONS.

By Dr. CHARLES WALDSTEIN.

THE following passage in De Quincey's "Walking Stewart" is well worth noticing: "The character of a nation may be judged of in this particular, by examining its idiomatic language. The French, in whom the lower forms of passion are constantly bubbling up from the shallow and superficial character of their feelings, have appropriated all the phrases of passion to the service of trivial and ordinary life, and

hence they have no language of passion for the service of poetry, or of occasions really demanding it, for it has been already enfeebled by continual association with cases of an unimpassioned order. But a character of deeper passion has a perpetual standard in itself, by which as by an instinct it tries all cases, and rejects the language of passion as disproportionate and ludicrous where it is not fully justified. 'Ah, Heavens!' or 'O my God!' are exclamations with us so exclusively reserved for cases of profound interest that, on hearing a woman even (i. e., a person of the sex most easily excited) utter such words, we look round expecting to see her child in some situation of danger. But in France, 'Ciel!' and 'O mon Dieu!' are uttered by every woman if a mouse does but run across the floor. The ignorant and the thoughtless, however, will continue to class the English character under the phlegmatic temperament, while the philosopher will perceive that it is the exact polar antithesis to a phlegmatic character."

There is a great amount of truth in this passage. The too frequent use of strong language may indurate and blunt onr feelings, as excessive indulgence in alcoholic stimulants deadens the sensibility of our palate. And there can hardly be a doubt but that the frequent use of words disproportionate in their strength to the thoughts and feelings in whose connection they are used has detracted from the original strength of the French language. Naturally the strongest word ought to be used to give expression to the strongest feeling. But strong words have been so blunted through frequent use that they have lost their sharp edge, and pass over our thick skin without even pricking our sensibility; while, at moments when we expect a heavy blow, the light tickling of the socially polite feather may far more vividly stimulate our sensibility. It may be said that this disparate use of words is the essence of sarcasm, and that sarcasm is naturally strong. But the use of sarcasm itself indicates an abnormal state of mind, and its frequent cultivation during a certain epoch, or in a certain country, is almost an infallible symptom of disease in some quarter. When polite and otherwise weak words are used in a powerful context, it is almost invariably a sign of over-frequent and hackneyed use of strong words. There are many instances of this in France. Among them let us examine one of recent date and of great interest, because of its publicity and because of its author—the most powerful writer of the age. Of all Victor Hugo's writings this letter is one of the most characteristic specimens; not because of the strong words of which it consists, but, on the contrary, because of the colloquial, polite phraseology with which it begins, on an occasion when one would rightly expect the words which are used when—a stray dog has sprinkled a drop of mud on our newly-blacked boots.

"MONSIEUR: Vous faites une imprudence." (We expected an outburst of deeply-felt passion.). . . . "Tout cela a été dit. Je n'y insiste pas. Je dédaigne *un peu* les choses inutiles.

"Vous insultez Voltaire, et vous me faites l'honneur de m'injurier. C'est votre affaire.

"Nous sommes, vous et moi, deux hommes quelconque. L'avenir jugera. Vous dites que je suis vieux, et vous me faites entendre que vous êtes jeune. *Je le crois.*

"Le sens moral est encore si peu formé chez vous, que vous me faites 'une honte' de ce qui est mon honneur.

"Vous prétendez, monsieur, me faire la leçon. De quel droit? Qui êtes-vous? Allons au fait. Le fait le voici: Qu'est-ce que c'est que votre conscience, et qu'est-ce que c'est que la mienne?

"Comparons-les.

"Un rapprochement suffira," etc.[1]

And now he launches into a grand and dignified comparison, in which the words used are quite adequate to the weight of the feelings expressed.

No doubt there are other elements which contribute their share to make this letter so strong in style: as, for example, the great *crescendo* of the whole, which gradually and with a continual bridling in shows us the growing speed and bulk of his feelings, until they burst forth in grandeur. Then, again, we feel that the person who wrote this is on the one hand a man of the world, who can constrain passionate outbursts, and this prepares us for the subsequent great effect when his passion is let loose; for the man of the world is not the man of the street, who uses weighty language for light occasions. Ou the other hand, we hardly need fear, with Victor Hugo, that we may find the "typical" man of the world who has lost all power of passion in habitually repressing it; and we are prepared to receive the full meaning of deep words when they come.

However, the passage exemplifies what I mean. Instead of the word "imprudence," we expect something meaning unworthy, immora' action, or insolence. Instead of "un peu," we expect "profondément," etc. It will be seen that the whole beginning is in a tone of lightness which we would almost expect to notice in two gentlemen conversing in some public place quite simply, though without smiling. Still the essence which underlies the form is intensely passionate.

The reaction against this abuse of strong language may lead, on the one hand, to this disproportionate use of lighter words, or, on the

[1] "Sir, you are indiscreet. . . . That has already been said. I do not insist upon it. I *rather despise* useless things.

"You insult Voltaire, and you do me the honor to revile me. That is your affair.

"You and I are two men—what manner of men the future will decide. You say I am old, and you give me to understand that you are young. *I believe it.*

"In you the moral sense is still so undeveloped that you pronounce that in me 'a shame' which is my honor.

"You presume, sir, to read me a lecture. By what right? Who are you? Let us come down to facts. Here is fact: What is your conscience, and what is mine?

"Compare the two.

"A comparison will be enough," etc.

other hand, to a return to coarseness. In coarseness there is still an element of strength; the terse monosyllable which Bayard gave as a retort to the summons of surrender is an instance. Had he said, "Après vous, messieurs!" it would almost have been equally strong. The coarseness of some of the earlier English novelists, I think, was chiefly a reaction against the French manners of former periods. In my limited personal experience, I have found that many young men, who had spent their days with the ideal of "good form" before them, have taken a childlike delight in using vulgar language when free from restraint.

Language is to a certain extent an indicator of national character. But we must not be led to a one-sided statement of the case. There is an abuse, as well in the neglect or disuse of words expressive of feeling as in the too facile application of such words. And I believe that there is a faulty implication in De Quincey's remark quoted above, especially in its application to the English character—the implication, namely, that, where there is no verbal demonstration of feeling, we may infer a greater depth of feeling. In fact, one frequently hears this asserted, and the proverb, "Still waters run deep," has contributed to confirm such a belief. But this must not be hastily accepted. I believe that it is the extreme and just opposition against the equally faulty assertion that, where there is no demonstrative feeling, there is no feeling whatever. Falsehood, luckily, is not the normal manner of expression, notwithstanding the proposition that "*la parole a été donné à l'homme pour cacher sa pensée;*"[1] and therefore I am inclined to believe that, *cæteris paribus*, feeling is more likely to be present where we can perceive the outward signs of its existence, than where there is no sign whatever; as I am more inclined to believe that preciseness and firmness of character are more likely to be possessed by the man who takes great pains with the neatness and cleanliness of his person and attire than by one who does not. But there are action and reaction between the care of the person and the cast of the character; e. g., cleanliness may be the outward expression of certain traits of character, and when practised may again produce, or strengthen, or prolong these traits. All education rests upon the fact of this interaction. We see what is the desirable cast of mind by its outward manifestations, and try to ingraft such a mental attitude by habitual practice of these manifestations. It has been suggested to me in conversation that the fact of the lower orders, especially in the country, wearing their "Sunday best," and generally attending to the neatness of their appearance on Sundays, has a reviving and improving effect upon them. The workday customs, with rough language and more or less brutal indulgences, are cast away with the work-day clothes, and there is a strong feeling that outbursts would be out of keeping with such fine dress, and that a man must act up to his (genteel) appearance.

[1] Language was given to man to hide his thoughts.

Words are not merely the indications of feeling, but they may also react upon our feelings, modify them, in some cases even produce new groups of emotions.

If the emotions are a desirable and essential element of the human mind, and if language can thus react upon our emotional nature, the expression of these desirable emotions ought not to be neglected, but even positively cultivated. If we compare the German language with the English, we are struck by the poverty of the latter as regards the expression of emotions, and especially of those indicating contentment.

The wealth of the German language in expressions of feeling and general moods admits of no doubt. In what language do we meet with such a wealth of words expressing mental pain, from the most marked shadings down to the finest, until pain gently overlaps into pleasure? Let us attempt an incomplete enumeration of such expressions, omitting the numerous foreign words (such as Melancholie, Apathie, Misere, Agonie, Tortur, etc.), which have been embodied in German idiom: Verzweiflung, Marter, Pein, Jammer (Herzensjammer), Elend, Gram, Kummer, Leid (Herzeleid), Herzensnoth, Herzensangst, Bangen, Trauer, Harm, Betrübniss, Trübsal, Trübsinn, Unglück, Schmerz, Weh, Unlust, Schmachten, Hinschmachten, Hindarben, Vergehen, Hinbrüten, Schwermuth, Wehmuth, Sehnsucht, Sehnen, Drängen, etc. Besides these there are numerous expressive compounds.

Now, it is true that the German, as well as every language, is richer in words expressive of grief than of joy; and this is a characteristic common to all language, because it springs from psychological facts common to all men. We do not so readily express our joy as our grief, because, in the first place, grief is more dignified than joy. We do not like to show our joy, because it is easily unbridled, and the boundless is less comely than the bounded. Joy is elation, which implies opposition to the usual fetters and to form; while grief is a contraction, which implies a closer sinking into form, and seeks the plastic. The facial expression of joy and grief corresponds to this—nay, perhaps was a cause in determining our inclination or repugnance as regards the expression of these emotions. Joy manifests itself in an expansion of the facial muscles, and avoids the eye of the sculptor who wishes to render a beautiful harmonious display of features. The sinking and contraction of grief, on the other hand, bring out more markedly the fine features and the modeling. Then, again, elation means motion and unrest; it points to restless diffusion, while contraction must end, and points to quiet and rest; and therefore sculptors, to whom to a great extent we owe the creation of the ideal of human beauty, rendered the latter and shunned the former.

In the second place, sympathy, if sought by the happy, is less sure to be obtained; for man has the evil tendency to envy, and, though it is easy for him to feel the delight of compassion and pity, he is more grudging with his sympathy with others' joy. He has also the ten-

dency to egoism. Joy has less need of sympathy: the happy are apt to be self-sufficient. He can afford to share some of his pain with his brethren; but joy is a matter much in demand, and he cannot well spare a particle of it—that, unless it can be increased by division, is devoured alone.

And, finally, there are fewer expressions of joy, because contentment is essentially a unit, is one, or at least is so in its perfect state, toward which we strive. There is a homely German saying, "Satter wie satt kann man nicht werden." Satiety is the *one* point, and all that is above or below this point is not enjoyable. When we are contented we have arrived at the normal state of existence; there is no other way of expressing it, for it is unique, and cannot be split into various shadings. And we are generally driven to express different shadings of joy by the physical concomitants of that feeling, as elation, thrilling, etc. It is the one positive point.[1]

All these causes will evidently influence lyric poetry, the musically-poetical expression of emotions. It is very difficult to say more than that we are happy, while we may tell many things of our peculiar feelings of misfortune. And we are not inclined to show our smiling face without hope of having it reciprocated; while we may fail to reproduce in our readers the sad mood which drove us to write a sad poem and still not feel ridiculous. The measured tone of sad words and their context is more adapted to musical rhythm than the rapid, short expressions of mirth. As in sculpture the woful expression is more plastical than the joyful, so in poetry the sad strives toward harmonious form more readily than the happy, and therefore we shall have fewer poems expressive of joy than of sorrow.

But to return to the main topic: The greatest distinction between the German and English language is perceived when we compare the expressions of the bright side of emotions. Let us again attempt an incomplete enumeration, omitting the numerous foreign words adopted into the German language, as well as the compounds which express so definitely certain fine shadings: Entzücken, Ergötzen, Tubel, Wonne, Seligkeit, Glückseligkeit, Freude, Freudigkeit, Glück, Lust, Vergnügnen, Frohsinn, Frohmuth, Heiterkeit, Munterkeit, Scherzhaftigkeit, Ausge-

[1] I hold, in opposition to the pessimists, that this fact of the poverty of expressions of pleasure as contrasted with the multiplicity of expressions of pain goes to prove the *positive* nature of pleasure. The pessimists hold that pain is positive and pleasure negative, i. e., that pleasure is the absence of pain; the intermissions in the long chain of bodily and mental pains are to them pleasure. In logic the positive thing is definite and one, while the negative is indefinite and multiple. So "A" would be positive, definite, and would denote one thing; while "Not A" is negative, indefinite, in fact, denotes anything or all things in the universe excepting "A." Therefore, when the pessimist points to the wealth of expression in pain, and to the poverty in expressions of pleasure, and when he points to the difficulty of defining contentment, while pain comprises so many states, he has not disproved the positive nature of pleasure. On the contrary, we find that the simpler and more positive a fact is, the more difficult is it to define, until we are limited to the mere mention of the fact.

lassenheit, Launigkeit, Schalkhaftigkeit, Wohlbehagen, Zufriedenheit, Gemüthsruhe, etc.

Now, some of these words have been and are still in use in the English language ; but they have suffered strange usage. They have degenerated to lightness, losing their original weight and dignity, or they have been actually lowered and have received an evil connotation. And we generally find that the Latinized words degenerate in the direction of levity, while the Saxon words degenerate in the direction of vulgarity.

As an instance of the first case, the English words corresponding to Glück and Unglück are Fortune and Misfortune. The dark side of these ideas, Misfortune, has retained the strength and dignity corresponding to the German. Fortune, however, does not correspond to Glück as Misfortune corresponds to Unglück. It may be urged that Fortune had already lost its deep meaning in the Latin, perhaps because of the fickle and worldly character which poets attributed to the goddess Fortuna ; but the difference in the comparative depth of signification between Fortune and Misfortune illustrates what I mean. Fortune has more and more turned toward a signification of luck or chance, or to an expression of the most worldly accidents of happiness, as wealth, etc. When the German says, "Ich bin glücklich," he means to indicate a state of high satisfaction ; but, when we say, "I am fortunate," it conveys the impression of a transitory state of satisfaction ; in fact, we are not necessarily happy or contented, the accent is not thrown upon our own mood, but upon some outer fact, for we would naturally ask, "Fortunate *in what?*"

As an instance of the second case, we find the word Lust still used in English, but in what an altered meaning from the German ! In German, Lust denotes a wide, high, and intense pleasure. It would not be amiss in German to speak of the "high Lust of the converse with God in prayer."[1] The wide compass of this word is beautifully illustrated in that untranslatable poem in Goethe's "West-oestlicher Divan," in which Lust is brought in connection with rose-water which cost the life of a whole world of flowers, and with the great historical event of Tamerlane's (Timour) inroad which also cost the life of myriads of existences :

"Dir mit Wohlgeruch zu kosen,
Deine Freuden zu erhöhn,
Knospend müssen tausend Rosen
Erst in Gluthen untergehn.

"Um ein Fläschchen zu besitzen
Das den Ruch auf ewig hält,
Schlank wie deine Fingerspitzen
Da bedarf es einer Welt ;

[1] We are reminded of the story of a German missionary in Australia, who, ignorant of this degeneration of Saxon words, exhorted his congregation "to do the will of God with *craft* and *lust*."

"Einer Welt von Lebenstrieben,
Die, in ihrer Fülle Drang,
Ahneten schon Bulbuls Lieben,
Seeleregenden Gesang.

"Sollte jene Qual uns quälen,
Da sie unsre Lust vermehrt?
Hat nicht Myriaden Seelen
Timur's Herrschaft aufgezehrt?"

It is true, the word Lust in English is not exclusively used in the lowest animal sense, but has been applied in a more intellectual connection; so we speak of the "lust of empire," the "lust of power," etc. But there is undoubtedly always an admixture of evil and of disapproval, and some hidden analogy to animal desire. With Chaucer, still, "luste" is used both as a noun and verb to signify wish, desire, pleasure, enjoyment, without an evil connotation.[1] The causes of this degeneration are numerous. But two seem to me most worthy of notice. It is a well-known fact that, after the Norman Conquest, the language of the conqueror, French, became the language of the aristocracy. This

[1] In the "Canterbury Tales:"

Clerkes Tale.

"His lustes were al lawe in his decree
For fortune as his friend wolde him obeye.

Right as you lust governe the matter.

Wherefore I yow preye
Doth your plesaunce, I wol your lust obeye.

But on his lust present was al his thought
As for to hauke and hunt on every syde."

Squyeres Tale.

"But thus llete in lust and iolitee
This Cambyskam his lordes festeyinge
Til wel ny the day began to springe.

The knotte why that every tale is told
If it be taried til the lust is cold.

If hir lust it for to were
Upon hir thombe."

Man of Lawes Tale.

"Al his lust and al his busy care
Was for to love hir while his lyf may dure."

"To do hir lust" (will, pleasure) is very common, and originally lust was used in the sense of list (the *opposite* sense, listless, still obtains), to do anything with pleasure, enjoyment. The word *lusty* Chaucer also uses like the German *lustig*, meaning merry, jovial (the lusty playne, the lusty somer, etc.). The noun lustiheed (joviality), corresponding to the German Lustigkeit, is also used:

"Therefore I passe of al this lustiheed."
(*Squyeres Tale.*)

has manifested itself in the fact that the raw materials of food—cattle, etc.—retained their Saxon names, such as calf, ox, sheep, etc., while the prepared meat is called by the French terms, beef, veal, mutton. Words used by the aristocracy will retain a high and polite signification, while the corresponding words in Saxon used by the vulgar will be spurned by the higher classes, and will receive a vulgar stamp.

Another striking instance of the vulgarizing influence of the Norman Conquest upon the Saxon vernacular is afforded by the word "buxom." In Anglo-Saxon *beogan*, *bugan*, and *bocsum*, it still obtains in the German, *biegen*, *biegsam*. In German it has retained its original meaning of bendable, pliable, slender, etc. In a mental sense it meant obedient (pliable), as "Under obedience to be and buxum to the lawe" ("Piers Plowman," about A. D. 1362). In Chaucer ("Clerkes Tale") we have it in its original physical meaning: "And they with humble entent buxumly—knelynge upon hir knees ful reverently." But in English we find a strange alteration in its meaning as applied to the human female figure. I may venture upon the following hypothesis with regard to the history of this word: Originally, I believe, this word was applied to the female figure to denote grace, litheness, slimness. If I remember rightly, some modern poet uses the word in that sense; the "buxom willow," or in some similar context. It would then convey the attribute of pliability and grace which is given in the words of Musset addressed to a lady: "Dans nos valses joyeuses je vous sentait dans mes bras plier comme un roseau." So, I venture to say, the word buxom was frequently applied to graceful, slender girls as a mark of high admiration. After the Norman Conquest, I suppose this to have been the action on the part of those who struck the key-note of *bon-ton*. Consciously, or half-consciously, the following train of thought seems to have pressed itself upon those of a markedly aristocratic turn of mind: "The people is essentially a distinct body from us, the aristocracy, especially the woman whom we admire so much. The words of the people must denote the attributes of the people: the lady is graceful, etc.; the woman is healthy, stout, red-cheeked, etc.—the lady dances, and we can feel her 'se plier comme un roseau,' but not the peasant-woman." Now, they found the word buxom indicating beauty in the woman of the people, they therefore influenced language, so that "buxom" conveyed the meaning of the beauty peculiar to the woman of the people.

Such a process is not restricted to the historical development of England; but we meet with it repeatedly in history, whenever there is this bloodless intellectual and linguistic warfare between classes. In Germany, e. g., the purely German words were repressed in meaning in proportion as the French gained footing as the language of the courts and of polite society through Frederick the Great and the subsequent Napoleonic influence. The Frau and Frauenzimmer assumed a lower connotation the more the word "madame" was used in connection with

ladies. At present there is a strong reaction against the French idiom in German. Politics and language are closely linked together in their bearing upon one another, and loss in political prestige precedes repression of idiom.

During the time of the Revolution we might have expected a revival of the old word, such as Lust; but the Revolution was puritanic in spirit, and so, instead of being reinstated it was still more repressed, for Puritanism with its stern features was ever averse to expressions of joyful emotions. Only such joy as partook of a lofty, aspiring character was cultivated, and the amiable and light-hearted was immediately stamped as frivolous. I think we must look to Puritanism for an explanation of one curious fact in these expressions. We find many expressions of exalted joy, of temporary pleasurable states (as a contribution from the French), and of the lower pleasure which is to be spurned. But we hardly find a powerful word which expresses a lasting state of pleasure, comprising as well the smallest satisfaction as the loftiest happiness—I mean a word corresponding to the German Glückseligkeit and the Greek *εὐδαιμονία*. In the German word the "glück" comprises all real happiness of life, and the "seligkeit" the most exalted spiritual happiness, and both combine to a lasting positive whole. A person would hardly be shocked were an Epicurean (a follower of the philosophy of Epicurus, I mean) to tell him that "Glückseligkeit was the aim of life," for this would include the highest moral satisfaction; while many people would be shocked to hear that "pleasure," or even "happiness, is the aim of life." This I attribute chiefly to the fact that the Puritan spirit drew a marked line between pleasures: there were exalted pleasures, and there were low pleasures; the first are desirable, the rest are to be repudiated, and there is no middle way.

This spirit, of course, did not always reign supreme, and the natural tendency is never totally to be extinguished, and we have some Saxon expressions of light mirth. But to this spirit, and other natural and historical causes, I attribute the fact that the dark side of expressions has been developed in England out of proportion with the bright side. So, for instance, we find that the German word Mitgefühl is rendered by the English "sympathy." This word, which means a "feeling with," originally meant a "suffering with." But while the German can subdivide this "feeling with" into with-joy and with-suffering (Gönnen, Mitfreude, and Mitleid), the English have two expressions of with-suffering, compassion, and pity, but have no expression for with-joy. One may mention that congratulation [1] conveys this meaning; but, though

[1] A curious instance in actual life which corroborates my statement was told me by a friend. A *naïve* and open-hearted lady was complaining to my friend of the difficulty she experienced in expressing her gratification to a relative who had been blessed with a baby. "You see," naïvely said this feeling person, "I can hardly express to her how truly I experience her joy, how I the-very-opposite-of-grudge" (she needed the German

it originally meant a sharing of joy, it has degenerated into a far lighter sphere, and has become a mere word of polite language, so that the illiterate will hardly recognize the original meaning from its present use. To use that French word to convey a deep feeling would be like using the word "plaisir" in German to express deep joy. The effect is similar to what it is when Heine, after his protestation of deep feeling, bursts forth with the French "*Madame*, ich liebe sie!"

Now, I am inclined to believe that where there is no expression for such a feeling, and where we rarely find such feelings expressed in other ways, such feelings are not so likely to exist, and, in truth, the ideal of "good form," which cripples the nature of many young men at a time when their emotions are still developing, goes to suppress the expression of any such feelings. One may frequently hear young men express their disapproval of others; but I think that I am not making a hasty statement when I maintain that one hears young men expressing their approval of others far less frequently in England than in Germany, though it is not unmanly nor ungainly to express one's liking of a third person, and one's joy with another, and this expression may have good effects, as well upon the sociable character as upon the whole emotional nature of men.[1]

But "good form" and other causes are contributing to impoverish the English language in expressions of original emotions. We notice the avidity with which people grasp at slang, because it has such original life. Were it not for the wide-spread knowledge of Shakespeare, I verily believe that our emotional language would be sorely crippled. There are desirable emotions, and they can be cultivated. Language is a means of cultivating them. There is a great difference in the mental cast of those who know but one language and those who know several, even if they have never left their home. The latter are possessed of broader vision and feeling, they have *learned* new feelings. When we have learned the true meanings of the French word "chic" and the German word "Gemüthlichkeit," we may have learned something the existence of which was unknown to us before. If we can force people to express "Mitfreude" we may perhaps teach some how

"gönnen") "her the blessing. Had her child died, I should have had many expressions at my service."

[1] Niebuhr, the great admirer of Englishmen, has remarked: "It is quite a national trait not to dwell upon what concerns us personally, upon what fills our heart; and it is as unnatural to them to hear me speak of the topics upon which I feel strongly as it would be to do the same themselves. How I shall bless the time when this constraint will be over, when in my own land I shall listen to the joys and sorrows of others, not as a mere piece of news, but as a communication to which I have a right, and be as sure of a welcome when I lay open my own heart! I am far from attributing it to coldness in these good people. It is altogether national, and it is the same with every one I have known here, whatever their rank or calling, learning or sex."—(From "The Life and Letters of B. G. Niebuhr, with Essays, etc.," by the Chevalier Bunsen, Professors Brandis and Loebell; translated by M. Winkworth.)

to feel it. If the language is poor in expressions it can be made richer. Coining of words ought not to be condemned *a priori*. It is self-regulating. If a person thinks something worth thinking, or feels something worth feeling, and cannot find an adequate expression, let him coin a word—if possible, one which manifestly conveys his meaning. He will have to be careful, for the public will reject what is useless, ridicule a blunder, but perhaps adopt what is suitable.

BIOLOGY AND "WOMAN'S RIGHTS."

SINCE natural history was remodeled by Mr. Darwin it has been found capable of throwing valuable lights, previously little anticipated, upon topics quite unconnected with the origin and attributes of zoölogical or botanical species. Of this solidarity of the sciences—one supplying another with methods of inquiry—a striking instance is afforded by a recent work,[1] in which the doctrine of natural selection is successfully utilized in the study of certain political subjects. That further applications more or less analogous are still possible will scarcely be doubted. There is in particular one question now agitating human society which seems particularly to require such treatment. Every one knows that of late years a movement has sprung up to secure for women, as contradistinguished from men, certain rights, liberties, and powers, of which it is contended they have been arbitrarily and wrongfully deprived. To define this movement, and to formulate distinctly the demands of its supporters, is a scarcely possible task. Innovators and agitators of all kinds enjoy the advantage that they cannot be tied down to any fixed set of propositions by which and by whose logical consequences they are prepared to stand or fall. On the contrary, if one ground is found untenable, another is instantly taken up; what satisfies one champion of the cause is rejected by another; and what to-day is accepted as final—as in the case of the anti-vivisection movement—is to-morrow proclaimed a mere installment, and made the basis of fresh demands.

Perhaps we may best describe the movement as an attempt to obliterate all—save the purely structural—distinctions between man and woman, and to establish between them a complete identity of duties and functions in place of that separation which has more or less hitherto always existed. That certain speakers and writers, not content with mere identification, go on to inversion, and would assign to men the particular tasks now allotted to women, though a significant fact, need not detain our attention.

It is of no use laughing at this agitation as the outcome of a mere

[1] "Physics and Politics," by Walter Bagehot. ("International Scientific Series.")

"crotchet." In certain states of the moral atmosphere crotchets spread just as do epidemics—which they closely resemble—in certain conditions of the physical atmosphere and other surroundings of man. Who would attempt to deal with the cholera or the small-pox by ridicule, how pungent and incisive soever?

We purpose, therefore, to examine this movement in the light of the principles of natural selection, of differentiation, and specialization, and to inquire whether the relations of the sexes in the human species and the distribution of their respective functions are or are not in general harmony with what is observed in that portion of the animal kingdom which lies nearest to man—to wit, in the Mammalia. With the origin and history of the agitation, with the hopes and motives of its supporters, and with the ethical, sentimental, economical, and political arguments used on either side we have no direct concern.

Even a very superficial and popular survey of the class Mammalia will satisfy us that the structural differences between the males and the females of each species are by no means confined to the reproductive organs. The male ruminant, whale, bat, elephant, rodent, carnivore, or ape, is on the average a larger and heavier animal than his mate. The tiger, for instance, exceeds the tigress in size by a proportion of from ten to twenty per cent. In few, if any, species is the superior stature of the male more striking than in the one which approaches man most nearly in its physical development—the gorilla.

But the mere difference in size is not all; the female is scarcely in any normal case a mere miniature copy of the male. Her proportions differ; the head and the thorax are relatively smaller, the pelvis broader, the bones slighter, and the muscles less powerful. The male in many cases possesses offensive weapons which in the female are wanting. In illustration we need only refer to the tusks of the elephant and the boar, and the horns of many species of deer. On the contrary, there is no instance of a female mammal possessing any weapon which is not also found, to at least an equal degree, in the male.

Further, the superior size of the head in the male is not merely due to the more massive osseous growth needful for the support of tusks, horns, etc., but to a proportionately larger development of brain. Thus, according to the recent investigations of M. le Bon,[1] "taking the mean weight of seventeen brains of human males, of 154 to 164 centimetres in height, and comparing them with the brains of seventeen women of the same stature, we find between the two a difference of 172 grammes (nearly six ounces) in favor of the male."

Summing up these facts, commonplace but not the less important, we see that in the whole mammalian class, man included, the males are distinguished from the females, not merely by larger size, but by superior cerebral and thoracic development, and by the more general possession of offensive weapons. On the other hand, trite as the remark may

[1] *Comptes-Rendus*, lxxxvii., No. 2, p. 80.

seem, the organs for the nutrition of the young are exclusively confined to the female. Are we to suppose that these sexual differences are devoid of meaning, merely accidental, or artificial in their origin?

We must next inquire to what functional distinctions these structural differences correspond, and what is their signification? It is generally admitted that among animals of one and the same species the larger will be found to be the stronger, and generally speaking physically the superior. Exceptions doubtless occür, but, if we were to take one hundred men in normal health whose "fighting-weight" ranged from eleven to twelve stone each, and compare them with another hundred averaging a stone less, we should find the former set able to lift greater weights, strike harder blows, and in every way excel the second lot in athletic performances.

Again, it is found that the size of the chest, and consequent volume of the lungs, affords a very good standard by which the general vigor, the vital energy, of either man or beast, may be gauged. The more a man, free from corpulence, measures round the chest, the better are his stamina, and the greater his power to support fatigues and hardships. Of this fact the military and the sporting world are perfectly aware, and never fail to take it into account in estimating the eligibility of a recruit or the probable performances of an athlete.

Having seen, then, that male animals are not merely actually larger than their respective females, but surpass them proportionally in the size of the thorax, we naturally expect the former to be decidedly the stronger, gifted with a more intense and exuberant vitality. Nor are our expectations disappointed. The bodily strength of a cow is trifling indeed compared with that of a bull of the same breed. In races a filly is very frequently—merely as such—allowed to carry less weight than a horse. A lady gorilla would be in evil case indeed if her husband did not treat her with a gentleness and kindness which many of our own species would do well to imitate. And as to mankind—is not, perhaps, the most legitimate source of the very movement we are criticising an attempt to secure women against the superior strength of men? Yet at a meeting at Manchester a male agitator actually sought to deny the superior physical power of man, because it would be easy to find a fish-wife stronger than a cotton-weaver. The argument, being intensely illogical, was frantically applauded.

Persons are not, however, wanting who—while admitting the general inferiority of women to men in physical strength—contend that this weakness is the result of continued and systematic repression. Woman, they say, has been forcibly debarred from invigorating pursuits, and comparative feebleness is the natural result. We would ask such advocates whether this systematic repression has been also carried out among the lower mammals, and, if not, what is the origin of the weakness of the female sex in their case, which is at least as well marked as among mankind? Has the "subjugation" of woman had

its parallel in the "subjugation" of the cow, the mare, the ewe, the lioness?

That the women of the middle class in all civilized countries, and of the higher in some, would be much healthier and stronger if they took more exercise in the open air and swallowed less tea, we admit. But in that case we contend that their increased vigor would descend not to their daughters exclusively or specially, but to all their children.

Further, in some countries and among certain classes, a great amount of physical labor falls to the lot of the women, without their being thereby rendered equal in strength to the men. Among the North American aborigines the squaw has the monopoly of hard work, while her husband—save when on the chase or on the war-path—indulges in idleness. Yet he runs no risk on that account of being surpassed in strength by his wife, and ultimately finding himself in consequence "subjugated."

No less is the superior cerebral development of the male sex in the human species, to which we have already referred as an indisputable fact, devoid of functional importance. It has, indeed, been contended that the difference in weight between the brain of the two sexes is a mere "survival" from some lower state of civilization, or of existence which we may expect to see ultimately disappear. Such hopes, if they anywhere exist, must be abandoned in view of the results of M. le Bon, already quoted. This biologist finds that "the difference between the respective weight of the brain in man and woman constantly goes on increasing as we rise in the scale of civilization, so that as regards the mass of the brain, and consequently in intelligence, woman becomes more and more differentiated from man. The difference which exists between the mean of the crania of contemporary Parisian men and that of contemporary Parisian women is almost double the difference which existed in ancient Egypt.

Taking hold of this simple fact, that the brain in the male is not merely larger, but increasingly larger, than in the female, we need not long search for its meaning. As the same writer to whom we have referred declares, "On examining series of crania sufficiently numerous we find that in the human species the largest brains belong to the races highest endowed intellectually, and in each race to its most intelligent members." Just, therefore, as higher civilization is heralded, or at least evidenced, by increasing bulk of brain; just as the most intelligent and the dominant races surpass their rivals in cranial capacity; and just as in those races the leaders, whether in the sphere of thought or of action, are eminently large-brained—so we must naturally expect that man, surpassing woman in volume of brain, must surpass her in at least a proportionate degree in intellectual power. We are sorry to be compelled here to own that while we know that in most, if not all, mammalian species the brain of the male exceeds in size that of the female, we have no observations as to any corresponding difference in mental

power. That such difference, on careful examination, will be found to exist is highly probable; but we must likewise expect that it will be found less distinctly marked the lower the rank of the species.

To return: the intellectual superiority thus claimed for the male sex, in virtue of a higher cerebral development, is fully manifested in the history of the various arts and sciences. In every department the first, the leading, minds have belonged to the male sex. Homer, Shakespeare, Phidias, Beethoven, no less than Newton, Liebig, and Darwin, are men.

In reply to this historical confirmation of what biology foretells, the advocates of the movement adduce three arguments, all, in our opinion, singularly inconclusive.

Admitting the superiority of the male brain in bulk and weight to that of the female, they maintain the existence of a qualitative difference which renders the two incommensurable. This hypothesis, however, is a pure assumption. We should have an equal right to maintain that the brains of different races of men, especially as existing in ages widely remote from each other, were incapable of mutual comparison. Or, in the same spirit, it might even be urged that the smaller size of the muscles in woman was no proof of any inferiority in physical strength.

Secondly, it is contended by those who seek to identify the duties, functions, and spheres of action of the two sexes, that many women have distinguished themselves in the arts and sciences. Admitting to the full this fact, we can only place it on a level with the kindred phenomenon that not a few women have, in disguise, entered the army or navy, and have acquitted themselves as creditably as their male comrades; or that others have worked long and undetected as excavators, in the construction of railways, etc. The *savante*—the woman of science—like the female athlete, is simply an anomaly, an exceptional being, holding a position more or less intermediate between the two sexes. In the one case the brain, as in the other the muscular system, has undergone an abnormal development. That such cases should occur need no more surprise us than does the converse phenomenon, the existence of womanish man. We meet with subjects, otherwise of the male sex, in whom the beard is scanty or wanting, the limbs slight and rounded, the voice high, the chest narrow, and the pelvis broad, or who, if they do not structurally approximate to the female sex, betray a preference for feminine occupations, which wins for them such epithets as "molly-cots," "cot-queans," etc. At the risk of somewhat anticipating ourselves we cannot suppress the remark that no one demands especial laws and institutions for the benefit of such womanish men, or proposes their exemption from the customary duties of the male sex, how burdensome soever these may be felt.

The third and last plea put forward to explain, if possible, the cerebral inferiority of woman and her concomitant intellectual inferiority,

is an adaptation of the one already proposed to account for her smaller physical strength. It is gravely asserted that mental activity in art or science has been systematically repressed among women, and that in consequence their cerebral development has been injuriously interfered with. To this contention it would be a sufficient reply were we to simply point to the fact already mentioned, that the relative inferiority in the size of the brain of women, instead of diminishing as their social status has improved, has, on the contrary, been increasing. We may hence fairly argue that it exists not in virtue of any artificial interference, but of a law of Nature. We can, however, adduce other considerations. In the pursuit of the fine arts, woman, instead of being checked and hindered, whether by law or by social conventions, has been encouraged. An acquaintance with music has been literally forced upon every girl of the upper and middle classes. Yet, leaving composers out of the question, how many of the million female performers on the piano-forte, now to be found in Europe and America, can take rank with Liszt and Thalberg? In the highest development of literature, poetry, sex has been no obstacle to the recognition of merit. Yet neither Sappho in the past nor Mrs. Hemans and Mrs. Browning in our own day can be placed even in the same class with the leading poets of Greece, England, and Germany.

Women have certainly till of late met with few direct facilities for the pursuit of science. But, in England at least, neither have men. Our great scientific discoverers, until quite recent days, have been substantially self-taught, and even if in their youth they enjoyed a university education their subsequent researches, though *post hoc* (after this), have assuredly not been *propter hoc* (on account of this). Scientific books and apparatus have been as accessible to one sex as to the other; and these have generally been the only opportunities that our discoverers have had at their command. How to use such appliances they had to discover for themselves. We deny, therefore, that the exclusion of young women from universities, *in which modern sciences were not taught*, can have hindered them from entering upon a scientific career. Equally do we deny that public opinion forbade for them study and research. Had Miss Herschel been a man, her astronomical discoveries could not have been more highly or more deservedly appreciated. Not a dog barked at her for preferring determining the orbits of comets to ordinary feminine avocations. In like manner, if any woman had possessed the necessary faculties and turn of mind, there was nothing in the way of public prejudices or established customs to prevent her from having anticipated Dalton in discovering the laws of definite chemical combination. Nor, if thus discovered, would the "atomic theory" have met with a less favorable reception. We then entirely deny the existence of any supposed conspiracy to repress scientific talent in the female sex, and we hold that the three arguments adduced to explain its comparative rarity among women are utterly inconclusive.

A further distinction between the sexes, common to mankind and to all the mammalian class, must be sought in the moral faculties. Take what species we like we find the males bolder, more pugnacious and quarrelsome, more adventurous and restless, and less tractable and docile. The females, on the other hand, save in protection of their young from real or supposed danger, are mild, gentle, and inoffensive. Of this no more indisputable instance could be found than the case of domestic cattle, the cow—with the exception of certain "strong-minded" individuals—being perfectly harmless, while the bull, when above four years old, is one of the most dangerous animals known, attacking and killing human beings, not for food, like the lion or the tiger, but out of pure "superfluity of naughtiness." Very similar is the distinction between the character of the sexes among the Quadrumana. No animal is more wantonly and gratuitously mischievous than an adult male baboon, and we are unable to find an instance of one having been tamed so far that he could be allowed his liberty. The females, on the other hand, are capable of domestication. Were there any necessity to multiply instances a fair-sized volume might be filled with accounts of the intractability of male mammalia of different species, as contrasted with the mildness and docility of their females, while in no animal is the case reversed. That the sexual distinction of character in our own species is precisely analogous in its nature will, we trust, be admitted without argument.

We find, therefore, summing up the foregoing facts, that throughout the mammalian community the males are larger and heavier than the females, whom they, moreover, especially exceed in thoracic and cerebral development; that they are consequently stronger, more intensely animated, and in disposition bolder and fiercer. The very same differences are found in average men as compared with average women, with the additional peculiarity that here the superior size of brain expresses itself in higher intellectual power.

It would be ridiculous to suppose that all these diversities, structural and functional, are objectless, and do not imply a corresponding diversity of duties. This accordingly we find to be the case: The male, at least in all species which form unions of any degree of permanence—whether monogamous or polygamous—defends and protects the female and her young ones. Thus, if a herd of elephants is menaced, the most powerful tuskers take their station on the side where danger appears, while the females and the young are placed as far as possible out of harm's way. If bisons are attacked by wolves, the bulls form a circle inclosing the cows and calves. A similar order is adopted by wild-horses. A gorilla will encounter any danger in defense of his mate, and even among baboons the old males will face an approaching enemy while the weaker members of the troop make good their escape. A lion has been seen in the same manner covering the retreat of his lioness and her cubs.

Other examples might be given were it at all needful, but those already stated are surely sufficient to establish the principle. Among herbivorous and omnivorous species, where food is plentiful, there is no occasion for the male to take upon him the duties of provider, but among the Carnivora he frequently supports as well as defends his family. The lion is in this respect a well-known instance.

We find, therefore, that throughout the class Mammalia the respective tasks of the two sexes are precisely such as we find in our own species: the male is the defender and provider, wherever such defense and provision are necessary; the female is the nurse. The man who brings home to his wife his weekly earnings, his professional fees, or his share of the profits of a business, merely repeats on a higher scale the action of the lion who carries a deer or an antelope to his den. Each sex fulfills the tasks for which it is especially adapted by Nature, and anything like "subjugation" is utterly out of the question. Were the duties of the two sexes confounded together, or, still more, were they inverted—the female, for instance, going forth to face danger or to hunt for prey, while the male was left to nurse the young—the position of the species in the great and constant struggle for existence would be very decidedly altered for the worse. We must conclude, therefore, that the attempt to alter the present relations of the sexes is not a rebellion against some arbitrary law instituted by a despot or a majority—not an attempt to break the yoke of a mere convention; it is a struggle against Nature; a war undertaken to reverse the very conditions under which not man alone, but all mammalian species have reached their present development. Sentimental speakers and writers have commented on the well-known fact that even a very young boy will, to his utmost ability, defend his sister or female playmate, and have expressed a hope that this habit—the result of early training—would wear out, the female no longer needing and the male no longer offering protection. Alas! is the very same habit in the ape, the lion, or the bison, the result of a mistaken training, or of an old-world convention, to be laid aside in these enlightened days? What would be the position of a family of young lions if both their parents went forth to hunt? Yet very similar will be that of children if their mother, as well as their father, goes out to the daily toils of a profession, leaving them perhaps to themselves—perhaps to the care of ignorant and unprincipled hirelings. The results of mothers withdrawn from domestic duties, and spending their days in industrial pursuits, have been sufficiently exemplified in our manufacturing towns. Here, in the very highest interests of the race, it has been found necessary to check and limit female labor, which ought never to have been introduced. Had this precaution been taken, a man would have been able to earn as much as he and his wife jointly have been able to realize under the factory system. But what reason have we to expect that the introduction of female labor into professional spheres will prove a

greater boon either to the aspirants themselves or to the nation than it has been in the factory and the workshop? A friend, of original habits of thought, points out [1] that upon man alone was laid the penalty of labor as upon woman the sorrow of child-bearing. This is in fact the very same lesson, clothed in theological language, which we learn from biology. Among the lower animals, who, as compared with man, may be called the proletariate [2] of creation, both sexes indeed seem merely or mainly to exist in order to perpetuate their species. Still, even here, the female is more exclusively constructed for, and more totally absorbed in, the task of reproduction than the male. The share of the latter in this function is, strictly speaking, momentary, while during the stage of maturity the energies of the normal female are more or less completely devoted to the nurture, intra- and extra-uterine, of her offspring. Even when she never becomes a mother the generative system exercises a modifying influence upon her whole career. This consideration throws a strong light upon the ground taken by certain of the more "advanced" female advocates of the movement. The *femme libre* (free woman) of the new social order may, indeed, escape the charge of neglecting her family and her household by contending that it is "not her vocation to become a wife and a mother." Why then, we ask, is she constituted a woman at all? Merely that she should become a sort of second-rate man? We have already declared, and we repeat, that we wish a free career for every talent. If an abnormal woman possesses a man's muscular strength and adaptation for toil, we would not, either by law or by social influences, seek to debar her from working at the oar, or the forge, or even from wielding the policeman's truncheon or the soldier's rifle. But we would not calculate on such anomalies; we would not legislate for their special protection, or seek to increase their number. In a manner perfectly analogous, if a woman possesses the taste and the power for scientific research usually confined to men—and far from common even among them—we would not wish to restrain her from the cultivation of her peculiar faculties; but we would not foster the growth of such a class of females. We would not seek to entice women into the observatory, the laboratory, or, above all, into the dissecting-room, nor erect colleges for the training of *savantes*, any more than we would organize female regiments and open institutions where muscular young ladies might perfect themselves in the management of heavy artillery.

It is generally—too generally—assumed that every novelty, every change from what has hitherto been customary and recognized, commends itself, on the mere ground of its novelty, to men of science, as, indeed, to all unfettered inquirers, and will be resisted merely by those

[1] Genesis iii. 16, 17.

[2] As applied to the human species we consider this term eminently foolish. The man who benefits his race in no other way will probably injure it by leaving posterity like himself.

whose guiding principle is an unreasoning attachment to what is established. Never, perhaps, was it shown more clearly than with reference to the present question that innovation may be retrograde—that a proposed change, if carried out, may involve a return to a lower stage of development. What is the very essence of all advance to a higher stage of being, save differentiation? We see what was at first homogeneous, uniform in structure, become resolved into distinct tissues and members. We see functions which, in some rudimentary state, were jointly exercised by the whole body of an animal, gradually allotted out to special organs, and, during and in consequence of this very specialization, acquiring a far higher degree of perfection than they heretofore possessed. Look at the first rudimentary state—germ, seed, or ovum—of the plant or animal, and compare it with the mature organism to which it ultimately gives rise. What was one has become manifold; what was simple is now highly complex. The globule of albuminoid matter has developed into distinct members—sense-apparatus, organs respiratory, digestive, circulatory, locomotive, etc.—each of which has a separate task to fulfill, and is distinctly organized for that very purpose. It is no departure from our subject to remark that, though in the organic body one organ may, under certain circumstances, undertake the duties of another, such vicarious action involves grave peril to the organ concerned, and to the entire animal. Perhaps the world may yet find that the analogy between the individual and mankind holds good in this respect, and that a social congestion may follow from the movement we are examining.

To return: the increase of size which distinguishes the butterfly from the egg, or the oak from the acorn, is a trifling feature compared with the accompanying differentiation—chemical, morphological, and functional—which has taken place.

If we pass from a consideration of the individual plant or animal to a survey of the entire organic realms, we find, as we advance from the humblest and meanest beings to the highest, merely a repetition of the same great fact. At the one extremity of the scale—if this expression may still be used—we find beings whose senses, such as they are, must be exercised by the whole external surface of the body, those more special functions which we know as sight, hearing, etc., being still identical with feeling. No distinct nervous system, still less definite nerve-centres, can be traced. Nor are there any organs specially devoted to the processes of respiration, circulation, digestion, etc. A common internal cavity takes the place, and, in a crude way, fulfills the duties of all these parts. Externally the same uniformity prevails; there are no limbs, no members exclusively constructed for locomotion in any of its modes, or for prehension. The animal moves by elongating and contracting its whole body, or by rolling over. In many of the lower forms of animal life the sexes are not separated, the functions of the male and the female being exercised by one and the same individual.

It is a fact, long familiar to the world, that the polyp may be cut into without injury, each part soon becoming a complete animal.

To such simplicity of structure the completest contrast is afforded by the higher animals. Throughout their bodies we find a "division of labor," each function having its organ and each organ its distinct function. To trace how this differentiation is carried out would be wearisome, and, being admitted, is fortunately needless.

It may be useful, however, to call to mind the fact that animals which, when mature, are broadly and easily distinguished from each other, are more and more alike the earlier the stage of growth at which we institute a comparison. The differences between a baby chimpanzee and a human infant are much slighter than those between the adults of the respective species. If we extend our researches to the embryonic state we find that the rudimentary man can scarcely be distinguished from many of the other vertebrates. It is only, as Prof. Huxley points out, in the later stages of prenatal growth that the human fœtus differs from that of an ape. In the former the convolutions of the brain, according to Prof. Bischoff, reach about the same stage of development as in an adult baboon. The great toe, in man, is considered by Prof. Owen the most characteristic feature of the human skeleton; but, in an embryo about an inch in length, Prof. Wyman found this member not lying parallel with the other toes, but projecting out from the side of the foot as it does permanently in the so-called Quadrumana in their mature condition. Thus plainly does it appear that differentiation is the way to perfection, each animal as it approaches maturity diverging more and more from other forms, from which, in its earlier stages, it was scarcely distinguishable.

Yet again, we may turn from a survey of the growth of the individual, and from a comparison of the highest and lowest forms of contemporary organic life, to the consideration of the successive phases of being that have peopled our earth. Here, too, we find the same great law prevail. In the remote past we find what are called "generalized forms"—animals which seem to have combined in themselves the rough outlines of what we now find developed into perfectly distinct beings.

Suppose it were now proposed as an improvement in the structure of man, or of any other mammalian species, that the functions now exercised by two distinct organs—such as, e. g., the eye and the ear, or the nerves of motion and of sensation—should be "lumped" together, committed to one only set of organs; would such a change, if we for the moment suppose it practicable, be an advance or a retreat? Would it raise or lower the species in the scale of existence? It might seem a convenience if, instead of seeing with our eyes alone, we could also see and hear with our ears; but would either the seeing or the hearing be done as well as now, when each is the sole function of an express organ? On the principles of the old natural history, as well as of the

new, we may safely reply in the negative. The change we have supposed is fortunately incapable of being effected, otherwise the attempt would doubtless be made in the name of "progress."

But we may follow the principle of differentiation, and trace its workings over the boundaries of biology into those of sociology, if such a science can be said to exist. Where differences of structure can no longer be traced we still find differences of function. In man we find no variation in the number and position of bodily organs; yet identical organs in different individuals are trained to special tasks which to other men would be impossible, and which might seem to necessitate a structural difference. We come, that is to say, upon the division of labor, which is one of the most characteristic and essential features of civilization. We have seen that in the lowest forms of animal life the entire body seemed to subserve every vital process; just so in the lowest stages of human society, every individual is at once warrior, hunter, builder, maker of arms and other utensils, and—in as far as agriculture is practised at all—tiller of the soil. Every man is perforce, in the words of the adage, "Jack of all trades," with the inevitable consequence that he is "master of none." In a civilized nation, just as in the higher animals, all this is reversed. Every function has its special organ, or, in other words, every task is committed to a separate man or body of men. In all this we can trace out nothing that speaks of arbitrary interference or compulsion. In the animal or human body each function is committed to organs fitted for that function. The stomach does not protest because it is not the seat of respiration, nor does the heart crave to undertake the task of digestion, either instead of or along with its own duties. In human society—complain as we may about "square pegs" being placed in "round holes"—the different tasks are in the main assigned to the men most competent for their performance. In a savage tribe the strongest and bravest naturally leads in war; the man keenest of eye and ear becomes the scout, either as regards hostile tribes or beasts of the chase. The wisest and most eloquent—attributes which, if necessarily connected in primitive times, are now so no longer—took the foremost place in council. The man of greatest manual dexterity would be chief bow-maker to the tribe. The process in operation was, in fact, natural selection. The man who undertook a task for which he was unfitted, or less fitted than others, was gradually eliminated, as far as that particular task was concerned. In proportion as new wants sprung up and new means of gratifying them were devised, social functions were multiplied, and the division of labor became more minute. Yet even in the very rudest state, as far at least as anthropologists have been able to trace, there never was a time when the duties of all persons were absolutely identical. To men and to women different duties were assigned on the same principle of natural selection. Changes have, indeed, taken place in the distribution of the tasks respectively allotted to the two sexes. But these changes,

it is important to note, till the "woman's-rights' movement" sprung up, have all been in one direction—the direction of increasing differentiation. The distinction between men's work and women's work has been increased, not diminished. The barbarian and the semi-civilized nation allowed women to carry heavy burdens, to tug at the oar, to wield the spade, the hoe, the mattock, in the fields, and even to labor in mines. In our higher civilization such tasks are limited to man, and, as we have already remarked, to abnormal "mannish" women. The movement we are considering, in so far as it aims at breaking down the natural barriers between the duties of the two sexes, is palpably retrograde. If advancement toward perfection is reached by differentiation, *anti-differentiation*—if we may use the expression—whether structural or functional, must be a return to a lower condition. If the first and plainest step in the division of labor is to be abandoned, how can others be maintained?

It has been already pointed out in the *Quarterly Journal of Science* that among vertebrate animals the social unit of which nations are put together is the family, whether that be monogamous or polygamous. A community of rooks is made up of an assemblage of married couples. A tribe of baboons consists of a number of males, each one having his wives and offspring. Now the "woman's-rights' movement" not merely runs counter to Nature in the respects we have already shown, but it is open to the charge of seeking to destroy family life and to constitute society of individuals—of atoms instead of molecules. In so doing it tends toward the condition of things prevalent in certain insect-communities. But there the mass of the nation, and especially its working and fighting members, is composed of what are commonly called neuters. Of such an arrangement no trace prevails among vertebrate animals, and we do not therefore see how their example can afford us any practical precedent.

We have, therefore, in fine, full ground for maintaining that the "woman's-rights' movement" is an attempt to rear, by a process of "unnatural selection," a race of monstrosities—hostile alike to men, to normal women, to human society, and to the future development of our race. We know that the modern "honorary secretary" is always ready to exclaim, "Let heaven and earth perish, so my crotchet may be realized!" But we would bid him ask himself whether the end is worth the means.—*Quarterly Journal of Science.*

ANIMAL INTELLIGENCE.[1]

By GEORGE J. ROMANES.

ANIMAL INTELLIGENCE is a subject which has always been of considerable interest to philosophical minds; but, as most of you are probably aware, the interest attaching to this subject has of late years been greatly increased by the significance which it has acquired in relation to the theory of descent. The study of animal intelligence being thus, without question, fraught with high importance to the science of our time, in adducing before this illustrious assembly some of the results which that study has yielded, I shall endeavor to treat them in a manner purely scientific. I shall try, as much as possible, to avoid mere anecdote, except in so far as it is desirable that I should put you in possession of a few typical facts to illustrate the various principles which I shall have occasion to expound. I shall seek to render apparent the more important of the issues which the subject, as a whole, involves, as well as the considerations by which alone these issues can be legitimately settled. I shall attempt to state my own views with the utmost candor; and if I shall appear to ignore any arguments opposed to the conclusions at which I shall arrive, it will only be because I believe those arguments to admit of easy refutation. And, in order that my exposition may be sufficiently comprehensive, I shall endeavor to point out the relations that subsist between the intelligence of animals and the intelligence of man. The aim and scope of the present lecture will therefore be to discuss, as fully as time permits, the facts and the principles of Comparative Psychology.

As human intelligence is the only order of intelligence with which we are directly acquainted, and as it is, moreover, the highest order of intelligence known to science, we may most conveniently adopt it as our standard of comparison. I shall therefore begin by very briefly detailing those principles of human psychology which we shall afterward find to be of the most essential importance in their bearings on the subject which I have undertaken to discuss.

When I allow my eyes to travel over this vast assembly, my mind receives, through their instrumentality, a countless number of impressions. So far as these impressions enter into the general stream of my consciousness, they constitute what are called perceptions. Suppose, now, that I were to close my eyes, and to fix my attention on the memory of some particular perception which I had just experienced—say the memory of some particular face. This mental image of a previous perception would be what is called an idea. Lastly, suppose that I were to analyze a number of the faces which I had perceived, I

[1] An evening lecture delivered before the British Association at Dublin, August 16, 1878.

should find that, although no two of them are exactly alike, they all bear a certain general resemblance to one another. Thus from the multitude of faces which I now perceive it becomes possible for my mind to abstract from them all the essential qualities of a face as a face; and such a mental abstraction of qualities would then constitute what I might call my abstract idea of a face in general, as distinguished from my concrete idea, or memory, of any face in particular.

Thus, then, we have three stages: 1. That of immediate perception; 2. That of ideal representation of particular objects; and, 3. That of a generalized conception, or abstract idea, of a number of qualities which a whole class of objects agree in possessing. It will be convenient to split the latter division into two subdivisions, viz., abstract ideas which are sufficiently simple to be developed without the aid of language, and abstract ideas which are so complex as not to admit of development without the aid of language. As an instance of the former class of abstract ideas we may take the idea of food. This is aroused in our minds by the feeling of hunger; and, while the idea when thus aroused is clearly quite independent of language, it is no less clearly what is called an abstract idea. For it is by no means necessary that the idea of food which is present to the mind should be the idea of some special kind of food; on the contrary, the idea is usually that of food in *general*, and this idea it is which usually prompts us to seek for any kind of food in *particular*. Simple abstract ideas, therefore, may be formed without the assistance of language; and for this reason they are comprised within what has been called the Logic of Feelings. But abstract ideas of a more elaborated type can only be formed by the help of words, and are therefore comprised within what has been called the Logic of Signs. The manner in which language thus operates in the formation of highly-abstract ideas is easily explained. Because we see that a great many objects present a certain quality in common, such as redness, we find it convenient to give this quality a name; and having done this we speak of redness in the abstract, or as standing apart from any particular object. Our word "redness" then serves as a sign or symbol of a quality as apart from any particular object of which it may happen to be a quality; and having made this symbolical abstraction in the case of a simple quality, such as redness, we can afterward compound it with other symbolical abstractions, and so on till we arrive at verbal symbols of more and more complex qualities, as well as qualities further and further removed from immediate perception. By the help of these symbols, therefore, we climb into higher and higher regions of abstraction; by thinking in verbal signs, we think, as it were, with the semblance of thoughts, and by combining these signs in various ways, and giving the resulting compounds distinctive names, we are able to condense into single words, or signs, an enormous amount of meaning. So that, just as in mathematics the symbols which are employed contain, in an easily

manipulated form, the whole meaning of a long calculation, so in all other kinds of reasoning the symbols which we call words contain, in an abbreviated form, vast bodies of signification. Indeed, any one who investigates this subject cannot fail to become convinced that it is wholly impossible to over-estimate the value of language as thus the handmaid of thought; for, as we have seen, in the absence of language it would be impossible for thought to rise above the very simplest of abstract ideas, while in the presence of language it becomes possible for us consciously to predicate qualities, and so at last to feel that we are conscious of our own consciousness.

So much, then, for our classification of ideas. We have, first, simple ideas, or ideas of particular perceptions; and, secondly, abstract ideas, or ideas of general qualities; and the latter class I have subdivided into those which may be developed by simple feelings, and those which can only be developed by the aid of signs.

Now, with regard to ideas themselves, I need only add that they are the psychological units which compose the whole structure intellectual. They constitute, as it were, the raw material of thought, which may be elaborated by the reflective faculty into various products of thought. Once formed they present an essential property of occurring in concatenated series; so that the occurrence of one idea determines that of another with which it has been previously joined. This principle of the association of ideas, manifested as it is by the ultimate units of intellectual structure, is by far the most important principle in psychology: it is the principle which renders possible all the faculties of mind—memory, instinct, judgment, reason, emotion, conscience, and volition.

We are now in a position to investigate the facts of comparative psychology; and, in order to do so thoroughly, I shall begin by considering what I may term the physiological basis of mind. There is no reasonable doubt that all mental processes are accompanied by nervous processes; or, to adopt the convenient terms of Prof. Huxley, that psychosis is invariably associated with neurosis. The nature of this association, according to the best lights of our present knowledge, is probably as follows: Nerve-tissue consists of two elementary parts, viz., nerve-cells and nerve-fibres. The nerve-cells are usually collected into aggregates, which are called nerve-centres, and to these nerve-centres bundles of nerve-fibres come and go. The incoming nerve-fibres serve to conduct stimuli or impressions to the cells in the nerve-centre; and, when the cells thus receive a stimulus or impression, they liberate a discharge of nervous energy, which then courses down the outgoing nerve-fibres to be distributed either to other nerve-centres or else to muscles. It is in this way that nerve-centres are able to act in harmony with one another, and so to coördinate the action of the muscles over which they preside. This fundamental principle of neurosis is what physiologists call the principle of reflex action; and you will per-

ceive that all it requires for its manifestation is an incoming nerve, a nerve-centre, and an outgoing nerve, which together constitute what has been called a nervous arc. Now, there can be no reasonable doubt that in the complex structure of the brain one nervous arc is connected with another nervous arc, and this with another almost *ad infinitum*; and there can be equally little doubt that processes of thought are accompanied by nervous discharges taking place now in this arc and now in that one, according as the nerve-centre in each arc is excited to discharge its influence by receiving a discharge from some of the other nerve-arcs with which it is connected. Again, it is almost certain that the more frequently a nervous discharge takes place through a given group of nervous arcs, the more easy will it be for subsequent discharges to take place along the same routes—these routes having been thus rendered more permeable to the passage of subsequent discharges. So that in this physiological principle of reflex action we no doubt have the objective side of the psychological principle of the association of ideas. For it may be granted that a series of discharges taking place through the same group of nervous arcs will always be attended with the same occurrence of the same series of ideas; and it may be further granted that the previous passage of a series of discharges through any group of nervous arcs, by making the route more permeable, will have the effect of making subsequent discharges pursue the same course when started from the same origin. And, if these two propositions be granted, it follows that the tendency of ideas to *re*cur in the same order as that in which they have previously *oc*curred is merely a psychological expression of the physiological fact that lines of reflex discharge become more and more permeable by use. We thus see that the most fundamental of psychological principles—the association of ideas—is merely an obverse expression of the most fundamental neurological principles—reflex action. But here we have an important qualification to take into account. All reflex action, or neurosis, is not attended with ideation, or psychosis. In our own organization, for instance, it is only cerebral reflexes which are so attended; and even among cerebral reflexes there is good reason to believe that the greater number of them are not accompanied by conscious ideation; for analysis shows that it is only those cerebral discharges which have taken place comparatively seldom, and the passage of which is therefore comparatively slow, that are accompanied by any ideas, or changes of consciousness. The more habitual any action becomes, the less conscious do we require to be of its performance; it is, as we say, performed automatically, or without thought. Now, it is of great importance thus to observe that consciousness only emerges when cerebral reflexes are flowing along comparatively unaccustomed channels, and therefore that cerebral discharges which at first were accompanied by definite ideas may, by frequent repetition, cease to be accompanied by any ideas. It is of importance to observe this fact, because it serves to explain the origin of a number

of animal instincts. These instincts must originally have been of an intelligent nature; but the actions which they prompted, having through successive generations been frequently repeated, became at last organized into a purely mechanical reflex, and therefore now appear as actions which we call purely automatic or blindly instinctive. Thus, for instance, the scratching of graminivorous birds in earth and stones was no doubt originally an intelligent action, performed with the conscious purpose of uncovering seeds; but by frequent repetition through successive generations the action has now become blindly instinctive. This is shown by the following experiment: Dr. Allen Thomson tells me that he hatched out some chickens on a carpet, where he kept them for several days. They showed no inclination to scratch, because the stimulus supplied by the carpet to the soles of their feet was of too novel a character to call into action the hereditary instinct; but when Dr. Thomson sprinkled a little gravel on the carpet, and so supplied the appropriate or customary stimulus, the chickens immediately began their scratching movements. Yet, for aught that these chickens can have known to the contrary, there was as good a chance of finding seeds in the carpet as in the thin layer of gravel. And numberless other cases might be given to prove that animals acquire instincts by frequently repeating intelligent actions, just as we ourselves acquire, even in our individual lifetime, an instinct to adjust our nightcaps—an instinct which may become so pronounced as to assert itself even when a man is in the profound unconsciousness of apoplectic coma.

Thus we are able to explain all the more complicated among animal instincts as cases of "lapsed intelligence." But, on the other hand, a great many of the more simple instincts were probably evolved in a more simple way. That is to say, they have probably never been of an intelligent character, but have begun as merely accidental adjustments of the organism to its surroundings, and have then been laid hold upon by natural selection and developed into automatic reflexes. Take, for instance, the action of so-called "shamming dead," which is performed by certain insects and allied animals when in the presence of danger. That this is not a case of intelligent action we may feel quite sure, not only because it would be absurd to suppose that insects could have any such highly-abstract ideas as those of death and its conscious simulation, but also because Mr. Darwin tells me that he once made a number of observations on this subject, and in no case did he find that the attitude in which the animal shammed dead resembled that in which the animal really died. All, therefore, that "shamming dead" amounts to is an instinct to remain motionless, and therefore inconspicuous, in the presence of enemies; and it is easy to see that this instinct may have been developed by natural selection without ever having been of an intelligent nature—those individuals which were least inclined to run away from enemies being preserved rather than those which rendered themselves conspicuous by movement.

So that we thus see how animal instincts may arise in either of two different ways: for, on the one hand, they may arise from the performance of actions which were originally intelligent, but which by frequent repetition have become automatic; and, on the other hand, they may arise from survival of the fittest, preserving actions which, although never intelligent, yet happen to have been of benefit to the animals which first chanced to perform them. But now let it be observed that, although there is a great difference between these two kinds of instincts if regarded psychologically, there is no difference between them if regarded physiologically; for, regarded physiologically, both kinds of instincts are merely expressions of the fact that particular nerve-cells and fibres have been set apart to perform their reflexes automatically—that is, without being accompanied by intelligence.

So much, then, for what I have called the physiological basis of mind; and, in now taking leave of this part of my subject, I should like to point out that, in recognizing the indisputable fact of mind having such a basis, we are not necessarily committing ourselves to the doctrine of materialism. That psychical phenomena are very intimately associated with physical phenomena is a fact which does not admit of one moment's dispute; but concerning the nature of this association Science must declare, not merely that it is at present unknown, but that, so far as she is at present able to discern, it must forever remain unknowable. The restless tide of intellect for centuries has onward rolled, submerging in its every arm those strong and rugged shores whose name is Why; but at the line where mind and matter meet there rises, like a frowning cliff, a mighty mystery, and in the darkness of the place we hear the voice of true Philosophy proclaim, "Hitherto shalt thou come, but no farther, and here shall thy proud waves be stayed."

Passing on now to our review of comparative psychology, the first animals in which, so far as I can ascertain, we may be quite sure that reflex action is accompanied by ideation, are the insects. For Mr. Darwin has observed that bees remember the position of flowers which they have *only several times* visited, even though the flowers be concealed by intervening houses, etc. Sir John Lubbock also has shown that, *after a very few individual experiences*, bees are able to establish a definite association between particular colors on paper and food; and further that, *after a very few lessons*, a bee may be taught to find its way out of a glass jar. These observations would seem to prove that the grade of intelligence is higher in some Articulata than it is among the lower Vertebrata. For many of you will probably remember the experiment of Prof. Möbius, which proved that a pike requires three months to establish an association of ideas between particular kinds of prey and the fact of their being protected by an invisible wall. This fact was proved by the pike repeatedly dashing its nose against a glass partition in its tank in fruitless efforts to catch minnows which were

confined on the other side of the partition. At the end of three months, however, the requisite association was established, and the pike, having learned that its efforts were of no use, ceased to continue them. The sheet of glass was then removed; but the now firmly-established association of ideas never seems to have become disestablished, for the pike never afterward attacked the minnows, though it fed voraciously on all other kinds of fish. From which we see that a pike is very slow in forming his ideas, and no less slow in again unforming them—thus resembling many respectable members of a higher community, who spend one half of their lives in assimilating the obsolete ideas of their forefathers, and through the other half of their lives stick to these ideas as to the only possible truths; they can never learn when the hand of Science has removed a glass partition.

As regards the association of ideas by the higher vertebrated animals, it is only necessary to say that in all these animals, as in ourselves, this principle of association is the fundamental principle of their psychology; that in the more intelligent animals, associations are quickly formed, and when once formed are very persistent; and, in general, that, so far as animal ideation goes, the laws to which it is subject are identical with those under which our own ideation is performed.

Let us, then, next ask, "How far does animal ideation go?" The answer is most simple, although it is usually given in most erroneous form. It is usually said that animals do not possess the faculty of abstraction, and therefore that the distinction between animal intelligence and human intelligence consists in this—that animals are not able to form abstract ideas. But this statement is most erroneous. You will remember the distinction which I previously laid down between abstract ideas that may be developed by simple feelings, such as hunger, and abstract ideas that can only be developed by the aid of language. Well, remembering this distinction, we shall find that the only difference between animal intelligence and human intelligence consists in this—that animal intelligence is unable to elaborate that class of abstract ideas the formation of which depends on the faculty of speech. In other words, animals are quite as able to form abstract ideas as we are, if under abstract ideas we include general ideas of qualities which are so far simple as not to require to be fixed in our thoughts by names. For instance, if I see a fox prowling about a farm-yard, I cannot doubt that he has been led by hunger to visit a place where he has a general idea that a number of good things are to be fallen in with, just as I myself am led by a similar impulse to visit a restaurant. And, to take only one other instance, there can be no question that animals have a generalized conception of cause and effect. For example, I had a setter dog which was greatly afraid of thunder. One day a number of apples were being shot upon the wooden floor of an apple-room, and as each bag of apples was shot it produced through the rest of the house

a noise resembling that of distant thunder. My dog became terror-stricken at the sound; but, as soon as I brought him to the apple-room and showed him the true *cause* of the noise, he became again buoyant and cheerful as usual. Another dog I had used to play at tossing dry bones to give them the appearance of life. As an experiment, I one day attached a fine thread to a dry bone before giving him the latter to play with; and, after he had tossed the bone about for a while as usual, I stood a long way off and slowly began to draw it away from him. So soon as he perceived that the bone was really moving on its own account, his whole demeanor changed, and rushing under a sofa he waited horror-stricken to watch the uncanny spectacle of a dry bone coming to life. I have also greatly frightened this dog by blowing soap-bubbles along the floor; one of these he summoned courage enough to touch with his paw, but as soon as it vanished he ran out of the room, terrified at so mysterious a disappearance. Lastly, I have put this dog into a paroxysm of fear by taking him into a room alone and silently making a series of horrible grimaces. Although I had never in my life hurt this dog, he became greatly frightened at my unusual behavior, which so seriously conflicted with his general idea of uniformity in matters psychological. But I have tried this experiment with less intelligent dogs without any other result than that of causing them to bark at me.

Of course in thus claiming for animals the power of forming general conceptions, I mean only such general conceptions as can be arrived at by the logic of feelings. So far, then, as the logic of feelings can carry them, I maintain that the intellectual operations of animals are indistinguishable from those of ourselves. For having thus shown that animals possess the faculty of abstraction, I shall now go on to show that they possess the faculties both of judgment and of reason. My friend Dr. Rae, the well-known traveler and naturalist, knew a dog in Orkney which used to accompany his master to church on alternate Sundays. To do so he had to swim a channel about a mile wide; and before taking to the water he used to run about a mile to the north when the tide was flowing, and a nearly equal distance to the south when the tide was ebbing, "almost invariably calculating his distance so well that he landed at the nearest point to the church." In his letter to me Dr. Rae continues: "How the dog managed to calculate the strength of the spring and neap tides at their various rates of speed, and always to swim at the proper angle, is most surprising."

So much, then, for judgment. For some good instances of reasoning in animals I am also indebted to Dr. Rae. Desiring to obtain some arctic foxes, he set various kinds of traps; but, as the foxes knew these traps from previous experience, he was unsuccessful. Accordingly, he set a kind of trap with which the foxes in that part of the country were not acquainted. This consisted of a loaded gun set upon a stand pointing at the bait. A string connected the trigger of the

gun with the bait, so that when the fox seized the bait he discharged the gun, and thus committed suicide. In this arrangement the gun was separated from the bait by a distance of about twenty yards, and the string which connected the trigger with the bait was concealed throughout nearly its whole distance in the snow. The gun-trap thus set was successful in killing one fox, but not in killing a second; for the foxes afterward adopted either of two devices whereby to secure the bait without injuring themselves. One of these devices was to bite through the string at its exposed part near the trigger, and the other device was to burrow up to the bait through the snow at right angles to the line of fire, so that, although in this way they discharged the gun, they escaped without injury—the bait being pulled below the line of fire before the string was drawn sufficiently tight to discharge the gun. Now, both of these devices exhibited a wonderful degree of what I think must fairly be called power of reasoning. I have carefully interrogated Dr. Rae on all the circumstances of the case, and he tells me that in that part of the world traps are never set with strings, so that there can have been no special association in the foxes' minds between strings and traps. Moreover, after the death of fox number one, the track on the snow showed that fox number two, notwithstanding the temptation offered by the bait, had expended a great deal of scientific observation on the gun before he undertook to sever the cord. Lastly, with regard to burrowing at right angles to the line of fire, Dr. Rae and a friend in whom he has confidence observed the fact a sufficient number of times to satisfy themselves that the direction of the burrowing was really to be attributed to thought and not to chance.

I could give several other unequivocal instances of reasoning on the part of animals which I have myself observed; but time does not permit of my stating them. Passing on, therefore, to the emotional life of animals, we find that this is very slightly, if at all, developed in the lower orders, but remarkably well developed in the higher; that is to say, the emotions are vivid and easily excited, although they are shallow and evanescent. They thus differ from those of most civilized men in being more readily aroused and more impetuous while they last, though leaving behind them but little trace of their occurrence. As regards the particular emotions which occur among the higher animals, I can affirm from my own observations that all the following give unmistakable tokens of their presence: Fear, Affection, Passionateness, Pugnacity, Jealousy, Sympathy, Pride, Reverence, Emulation, Shame, Hate, Curiosity, Revenge, Cruelty, Emotion of the Ludicrous, and Emotion of the Beautiful. Now, this list includes nearly all the human emotions, except those which refer to religion and to the perception of the sublime. These, of course, are necessarily absent in animals, because they depend upon ideas of too abstract a nature to be reached by the mind when unaided by the logic of signs. Time prevents me from here detailing any of my observations or experiments

with regard to the emotional life of animals, so I will pass on at once to the faculty of Conscience. Of course, the moral sense, as it occurs in ourselves, involves ideas of high abstraction, so that in animals we can only expect to meet with a moral sense in a very rudimentary form; and, therefore, even if it is true that no indications of such a sense are to be met with in animals, the fact would not establish any difference in kind between animal intelligence and human. But I am inclined to believe that in highly-intelligent, highly-sympathetic, and tolerably well-treated animals, the germs of a moral sense become apparent. To give two instances: I once shut up a Skye terrier in a room by himself while I went to a friend's house. The dog must have been thrown into a violent passion at being left behind, for when I returned I found that he had torn the window-curtains to shreds. He was in great joy at seeing me; but as soon as I picked up one of the torn shreds of the curtains the animal gave a howl and ran screaming up the staircase. Now, this dog was never chastised in his life, so that I can only explain his conduct as an expression of the remorse which he suffered at having done in a passion what he knew would cause me annoyance. So far as I can interpret the facts, his sympathetic affection for me, coupled with the memory of his misdeeds, created in his mind a genuine feeling of *repentance.*

The other instance I have to narrate occurred with the same terrier. Only once in his life was he ever known to steal; and on this occasion, when very hungry, he took a cutlet from a table and carried it under a sofa. I saw him perform this act of larceny, but pretended not to have done so, and for a number of minutes he remained under the sofa with his feelings of hunger struggling against his feelings of duty. At last the latter triumphed; for he brought the stolen cutlet and laid it at my feet. Immediately after doing so he again ran under the sofa, and from this retreat no coaxing could draw him. Moreover, when I patted his head he turned away his face in a ludicrously conscience-stricken manner. Now, I regard this instance as particularly valuable, from the fact that the terrier in question had never been beaten, and hence that it cannot have been fear of bodily pain which prompted these actions. On the whole, therefore, I can only suppose that we have in these actions evidence of as high a development of the ethical faculty as is attainable by the logic of feelings when unassisted by the logic of signs—that is to say, a grade very nearly, if not quite, as high as that with which we meet in low savages, young children, many idiots, and uneducated deaf-mutes.

This allusion to savages, children, idiots, and deaf-mutes, leads me to the next division of my subject.

Prof. St. George Mivart has said that an interesting book might be written on the stupidity of animals. I am inclined to think that a still more interesting book might be written on the stupidity of savages. For it is a matter of not the least interest how much stupidity any

number of animals may present, so long as some animals present sufficient sagacity to supply data for the general theory of evolution; while, on the other hand, it is of the utmost importance for the science of this century to ascertain the lowest depths in which the mind of man is known to exist as human. Now, there is no doubt that the interval which separates the most degraded savage from the most intelligent animal is, psychologically considered, enormous; but, enormous as it is, I cannot see any evidence to show that the gulf may not have been bridged over during the countless ages of the past. Abstract ideas among savages are mostly confined to such as may be formed by the logic of the feelings; so that, for instance, according to the observations and the judgment of Mr. Francis Galton, the ideas of number which are presented by the lowest savages are certainly in no degree superior to those which are presented by the higher animals. Such ideas as savages possess seem to be mainly those which, as in animals, are due to special associations. On this account there is in them, as in animals, a remarkable tendency to act in accordance with preformed habits, rather than to strike out improved modes of action. On this account, also, there is, as in animals, a strong tendency to imitation as distinguished from origination. Again, as in animals, so in savages, the reflective power is of an extremely undeveloped character, and quite incapable of sustained application. And, lastly, the emotions of savages, as of animals, are vivid, although, as contrasted with the emotions of civilized man, they are in a marked degree more fitful, impetuous, shallow, and transitory. So that, altogether, I think the lowest savages supply us with a most valuable transition-stage between mind as we know it in ourselves, and mind as we see it manifested by the higher animals.

With regard to children it is to be expected, on the general theory of evolution by inheritance, that if we were attentively to study the order in which their mental faculties develop, we should find that the historical sequence is, as it were, a condensed epitome of the order in which these faculties were developed during the evolution of the human species. And this expectation is fairly well realized. Very young children present only those lower faculties of mind which in animals we call instincts. With advancing age, the first indication of true intelligence seems to consist in the power of forming special associations. Memory thus appears early in life; and, long before a child is able to speak, it links together in thought ideas of objects which it finds to be associated in fact. Again, the emotions begin to assert their presence at a very early period, and attain a high degree of development before any of the characteristically human faculties can be said to have appeared. Moreover, in young children we meet with nearly all the emotions which I have named as occurring in animals, and their general character is much of the same kind. In more advanced childhood the emotional life of children more resembles that of savages. With regard

to the more purely intellectual faculties, language is largely intelligible to a child long before it is itself able to articulate; but, soon after it is able to articulate, the faculty of abstracting qualities and classifying objects by the aid of signs begins its course of development. Thus, for instance, I have lately seen a child who belongs to one of the best of living observers, and who is just beginning to speak. This child called a duck "quack," and by special association it also called water "quack." By an appreciation of the resemblance of qualities, it next extended the term "quack" to denote all birds and insects on the one hand, and all fluid substances on the other. Lastly, by a still more delicate appreciation of resemblance, the child eventually called all coins "quack," because on the back of a French sou it had once seen the representation of an eagle. Hence to this child the sign "quack," from having originally had a very specialized meaning, became more and more extended in its signification, until it now serves to designate such apparently different objects as "fly," "wine," and "shilling." And as in this process we have the initiation of the logic of signs, so we have in it the potentiality of the most abstract thought. Accordingly, soon after a child begins to speak, we find that reason of a properly human kind begins to be developed.

Upon the whole, then, the study of infant psychology yields just the kind of results which the general theory of evolution would lead us to expect. But in comparing the intelligence of a young child with that of an adult animal we are met with this difficulty—that as the bodily powers of children at so immature an age are so insufficiently developed, the mind is not able, as in the case of animals, to accumulate experiences of life. In order, therefore, to obtain a fair parallel, we should require a human being whose mental powers have become arrested in their development at an early age, while the bodily powers have continued to develop to mature age, so serving to supply the aborted human intelligence with full experiences of life. Now, the nearest approach that we have to these conditions is to be found in the case of idiots. Accordingly, in anticipation of this lecture, I have sent a table of questions to all the leading authorities on idiocy, and the answers which I have obtained display a very substantial agreement. Through the kindness of these gentlemen I have also been enabled to examine personally a number of the patients who are under their charge. In particular I have to express my obligations to Drs. Beech, Crichton Browne, Langdon Down, Ireland, Maudsley, Savage, and Shuttleworth. On the present occasion I can only pause to state the leading facts which have been elicited by this inquiry.

As there are all degrees of idiocy, the object of my inquiry was to determine the order in which the various mental faculties become enfeebled and disappear as we descend from the higher to the lower grades of imbecility. On the general theory of evolution we should expect that in such a descending scale the characteristically human, or

the more recently developed, faculties should be the first to disappear, while those faculties which man shares with the lower animals should be the most persistent. And this expectation I have found to be fairly well realized. Beginning from below, the first dawn of intelligence in the ascending scale of idiots, as in the ascending scale of animals, is invariably to be found in the power of associating simple concrete ideas. Thus, there are very few idiots so destitute of intelligence that the appearance of food does not arouse in their minds the idea of eating; and, as we ascend in the scale idiotic, we find the principle of association progressively extending its influence, so that the mind is able, not only to establish a greater and greater number of special associations, but also to retain these associations with an ever-increasing power of memory. In the case of the higher idiots, as in the case of the higher animals, it is surprising in how considerable a degree the faculty of special association is developed, notwithstanding the dwarfed condition of all the higher faculties. Thus, for instance, it is not a difficult matter to teach a clever idiot to play dominos, in the same way as a clever dog has been taught to play dominos, viz., by teaching special associations between the optical appearances of the facets which the game requires to be brought together. But the idiot may be quite as unable as the dog to play at any game which involves the understanding of a simple *rationale*, such, for instance, as draughts. And, similarly, many of the higher idiots have been taught to recognize, by special association, the time on a watch; but it is remarkable that the high power of forming special associations which this fact implies occurs in the same minds which are unable to perform so simple a calculation as this: If it is ten minutes to three, how many minutes is it past two? Thus it will be seen that among idiots, as among animals, the faculty of forming special associations between concrete ideas attains a comparatively high degree of development. Let us then next turn to the faculties of abstraction and reason. Prepared as I was to expect these faculties to be the most deficient, I have been greatly surprised at the degree in which they are so. As regards the power of forming abstract ideas which depend on the logic of signs, it is only among the very highest class of idiots that any such power is apparent at all; and even here it is astonishing in how very small a degree this power is exhibited. There seems, for instance, to be an almost total absence of the idea of right and wrong as such; so that the faculty of conscience, properly so called, can rarely be said to be present. Most of the higher idiots, indeed, experience a feeling of remorse on offending the sympathies of those whom they love, just as did my dog on tearing the window-curtains; but I have been able to obtain very little evidence of any true idiot whose action is prompted by any idea of right and wrong in the abstract, or as apart from the idea of approbation and disapprobation of those whose good feeling he values.

Again, the faculty of reason is dwarfed to the utmost—so much so,

that the investigator is most of all astonished at the poverty of rational power which may be displayed by a human mind that in most other respects seems well developed. I can only wait to give you one example, but it may be taken as typical. A boy fourteen years of age, belonging to the highest class of undoubted idiots, could scarcely be called feeble-minded as regarded many of his faculties. Thus, for instance, his powers of memory were above the average, so that he had no difficulty in learning Latin, French, etc. Moreover, he could tell you by mental calculation the product of two numbers into two numbers, such as 35 by 35, or of one number into three numbers, such as number of days in nine years. His powers of mental calculation were therefore quite equal to those of any average boy of his age. Yet he was not able to answer any question that involved the simplest act of reason. Thus, when I asked him how many sixpences there are in a sovereign, he was quite unable to answer. Although he knew that there are two sixpences in a shilling, and twenty shillings in a sovereign, and could have immediately have said that twice twenty are forty, yet he could not perform the simple act of inference which the question involved. Again, I asked him, if he could buy oranges at a farthing each, how many he could he buy for twopence? He thought long and hard, saying, "I know that four farthings make a penny, and the oranges cost a farthing each; then how many could I buy for twopence? Ah! that's the question, and there's just the puzzle." Nor was he able by the utmost effort to solve the puzzle. This boy had a very just appreciation of his own physiological character. Alluding to his power of forming special associations and retaining them in his excellent memory, he observed: "Once put anything into my head and you don't get it out again very easily; but there's no use in asking me to do puzzles."

Lastly, the emotional life of all the higher idiots, as of all the higher animals, is remarkably vivid as compared with their intellectual life. All the emotions are present (except, perhaps, that of the sublime and the religious emotions), and they occur for the most part in the same order as to strength as that which I have already named in the case of animals. But, more than this, just as in animals, children, and savages, so in idiots, the emotions, although vivid and keen, are not profound. A trivial event will make the higher idiots laugh or cry, and it is easy to hurt their feelings with a slight offense; but the death of a dear relative is very soon forgotten, while the stronger passions, such as love, hate, ambition, etc., do not occur with that force and persistency which properly entitle them to be called by these names.

Upon the whole, then, with regard to idiots, it may be said that we have in them a natural experiment wherein the development of a human mind is arrested at some particular stage, while the body is allowed to continue its growth. Therefore, by arranging idiots in a descending

grade, we obtain, as it were, an inclined plane of human intelligence, which indicates the probable order in which the human faculties have appeared during the history of their development; and, on examining this inclined plane of human intelligence, we find that it runs suggestively parallel with the inclined plane of animal intelligence, as we descend from the higher to the lower forms of psychical life.

I have only time to treat of one other branch of my subject. Believing, as I have said, that language, or the logic of signs, plays so essential a part in developing the higher intellectual life of man, it occurred to me that a valuable test of the truth of this view was to be found in the mental condition of uneducated deaf-mutes. It often happens that deaf and dumb children of poor parents are so far neglected that they are never taught finger-language, or any other system of signs, whereby to converse with their fellow-creatures. The consequence, of course, is that these unfortunate children grow up in a state of intellectual isolation, which is almost as complete as that of any of the lower animals. Now, when such a child grows up and falls into the hands of some competent teacher, it may, of course, be educated, and is then in a position to record its experiences when in its state of intellectual isolation. I have, therefore, obtained all the evidence I can as to the mental condition of such persons, and I find that their testimony is perfectly uniform. In the absence of language, the mind is able to think in the logic of feelings, but can never rise to any ideas of higher abstraction than those which the logic of feelings supplies. The uneducated deaf-mutes have the same notions of right and wrong, cause and effect, and so on, as we have already seen that animals and idiots possess. They always think in the most concrete forms, as shown by their telling us when educated that so long as they were uneducated they always thought in pictures. Moreover, that they cannot attain to ideas of even the lowest degree of abstraction, is shown by the fact that in no one instance have I been able to find evidence of a deaf-mute who, prior to education, had evolved for himself any form of supernaturalism. And this, I think, is remarkable, not only because we might fairly suppose that some rude form of fetichism, or ghost-worship, would not be too abstract a system for the unaided mind of a civilized man to elaborate, but also because the mind in this case is not wholly unaided.[1] On the contrary, the friends of the deaf-mute usually do their utmost to communicate to his mind some idea of whatever form of religion they may happen to possess. Yet it is uniformly found that, in the absence of language, no idea of this kind can be communicated.

[1] Were it not for certain criticisms which have appeared on my lecture as originally delivered, I should have thought it unnecessary to point out that an uneducated deaf-mute inherits the cerebral structure of a man. The fact, therefore, of his having human feelings and expressions of face, as well as the capacity for education, is no proof that language is not necessary for the formation of abstract ideas, unless it could be proved that the human brain might have been what it is, even if the human race had never evolved any system of language.

For instance, the Rev. Mr. S. Smith tells me that one of his pupils, previous to education, supposed the Bible to have been printed by a printing-press in the sky, which was worked by printers of enormous strength—this being the only interpretation the deaf-mute could assign to the gestures whereby his parents sought to make him understand that they believed the Bible to contain a revelation from a God of power who lives in heaven. Similarly, Mr. Graham Bell informs me of another, though similar case, in which the deaf-mute supposed the object of going to church to be that of doing obeisance to the clergy.

On the whole, then, from the mental condition of uneducated deaf-mutes we learn the important lesson that, in the absence of language, the mind of a man is almost on a level with the mind of a brute in respect of its power of forming abstract ideas. So that all our lines of evidence converge to one conclusion: the only difference which analysis can show to obtain between the mind of man and the mind of the lower animals consists in this—that the mind of man has been able to develop the germ of rational thought which is undeveloped in the mind of animals, and that the development of this germ has been due to the power of abstraction which is rendered possible by the faculty of speech. I have, therefore, no hesitation in giving it as my opinion that the faculty of speech is alone the ultimate source of that enormous difference which now obtains between the mind of man and the mind of the lower animals. Is this source of difference adequate to distinguish the mind of man from the mind of the lower animals in kind? I leave you all to answer this question for yourselves. I am satisfied with my work if I have made it clear to you that the question, whether human intelligence differs from animal intelligence in kind or in degree, hinges entirely on the question whether the faculty of speech has been of an origin natural or supernatural. Still, to be candid, when the questions occur to me—Seeing that language is of such prodigious importance as a psychological instrument, does not the presence of language serve to distinguish us in kind from all other forms of life? How is it that no mere brute has ever learned to communicate with its fellows by words? Why has man alone of animals been gifted with the Logos?—I say, when these questions occur to me, I feel that, although from the absence of prehistorical knowledge I am not able to answer them, still, when I reflect on the delicacy of the conditions which, on the naturalistic hypotheses, must first have led to the beginning of articulate language—conditions not only anatomical and physiological, but also psychological and sociological—when I thus reflect, I cease to wonder that the complicated faculty of speech should only have become developed in *Homo sapiens*.

Ladies and gentlemen, I have now given you an organized epitome of the leading results which have been obtained by a study of the facts and the principles of comparative psychology; and, as in doing so I have chiefly sought to address those among you who are interested in

science, I fear that to some of you I must in many places have been very hard to follow. But as a general outcome of the whole lecture—as the great and vivifying principle by which all the facts are more or less connected, and made to spring into a living body of philosophic truth—I will ask you to retain in your memories one cardinal conclusion. We are living in a generation which has witnessed a revolution of thought unparalleled in the history of our race. I do not merely allude to the fact that this is a generation in which all the sciences, without exception, have made a leap of progress such as widely to surpass all previous eras of intellectual activity; but I allude to the fact that in the special science of biology it has been reserved for us to see the first rational enunciation, the first practical demonstration, and the first general acceptance, of the doctrine of evolution. And I allude to this fact as to a fact of unparalleled importance in the history of thought, not only because I know how completely it has transformed the study of life from a mere grouping of disconnected observations to a rational tracing of fundamental principles, but also because it is now plainly to be foreseen that what the philosophy of evolution has already accomplished is but an earnest of what it is destined to achieve. We know the results which have followed in the science of astronomy by the mathematical proof of the law of gravitation; and can we doubt that even more important results will follow in the much more complex science of biology from the practical proof of the law of evolution? I at least can entertain no doubt on this head; and, forasmuch as this enormous change in our means of knowledge and our modes of thought has been so largely due to the almost unaided labors of a single man, I do not hesitate to say, even before so critical an audience as this, that in all the history of science there is no single name worthy of a veneration more profound than the now immortal name of Charles Darwin.

Do you ask me why I close this lecture with such a panegyric on the philosophy of evolution? My answer is: If we have found that in the study of life the theory of descent is the key-note by which all the facts of our science are brought into harmonious relation, we cannot doubt that in our study of mind the theory of descent must be of an importance no less fundamental. And, indeed, even in this our time, which is marked by the first opening dawn of the science of psychology, we have but to look with eyes unprejudiced to see that the philosophy of evolution is here like a rising sun of truth, eclipsing all the lesser lights of previous philosophies, dispelling superstitions like vapors born of darkness, and revealing to our gladdened gaze the wonders of a world till now unseen. So that the cardinal conclusion which I desire you to take away, and to retain in your memories long after all the lesser features of this discourse shall have faded from your thoughts, is the conclusion that mind is everywhere one; and that the study of comparative psychology, no less than the study of comparative anatomy, has hitherto yielded results in full agreement with that great transfor-

mation in our view of things, which, as I have said, is without a parallel in the history of thought, and which it has been the great, the individual glory of this age and nation to achieve.—*Nineteenth Century.*

SKETCH OF DR. PETERMANN.

AUGUST HEINRICH PETERMANN, the world-renowned geographer, whose death under peculiarly painful circumstances was announced a few weeks ago, was born April 18, 1822, at Bleicherode, a small town in the Prussian province of Saxony. His parents destined him for the ministry of the church, and to this end sent him at an early age to the gymnasium or college of Nordhausen, one of the principal towns of his native province. Here he pursued the usual course of study in preparation for the university; but having in the mean time evinced a special liking and aptitude for geographical research, and especially for cartography, he abandoned the idea of entering the ministry, and gained admission to the Royal School of Geographical Art, founded three years previously at Potsdam by the well-known geographer Heinrich Berghaus, who was himself principal of the institution. Here Petermann remained for six years, first as a student, later as Berghaus's secretary and librarian, assisting him also in constructing and designing his great "Physical Atlas." Through this association with Berghaus, Petermann was brought into relations of friendship and intimacy with many of the great travelers and *savants* of the time in Germany, and in particular was so fortunate as to attract the favorable notice of Alexander von Humboldt, who in 1841 employed him to draw a map illustrating his great work, "Asie Centrale."

In 1845, on the completion of Berghaus's "Physical Atlas," Petermann went to Edinburgh, where for two years he assisted the late Alexander Keith Johnston in adapting that work for the use of English readers. From Edinburgh he went to London, whither the fame of his meritorious services to the science of geography had preceded him. He was elected to the Royal Geographical Society, and became one of its most active members. During the seven years which he passed in the British metropolis he weekly contributed to the *Athenæum* notices of geographical progress, reviews of books, and the like. He also wrote geographical articles for the "Encyclopædia Britannica" and for the "English Cyclopædia." In association with the Rev. Thomas Milner he prepared a popular "Atlas of Physical Geography;" he also published many separate maps. He was in no mean degree instrumental in promoting the Richardson-Barth-Overweg expedition sent out in 1849 by the British Government to explore Central Africa. Richardson having died at Unguratua in the spring of 1851, Barth succeeded to the leadership, and on his return to England published in three vol-

umes an account of his travels. The maps illustrating this work were, as the author writes in his preface, "executed with artistic skill and scientific precision by Dr. Petermann." Henceforward the exploration of the "dark continent" was one of the two dominant thoughts of Petermann's mind, the other being north-polar exploration. He has awakened throughout Europe a lively interest in both of these departments of research, and there is no doubt that to him is due much of the advancement made in geographical knowledge during the last thirty years; and recent German explorers of Africa, as Heuglin, Munzinger, Rohlfs, Mauch, Schweinfurth, and Nachtigal, found in Petermann a powerful advocate to enlist popular sympathy for their labors. In high northern exploration he was a believer in an open Polar Sea, therein agreeing with our own great navigators, Kane and Hall, but his favorite route to the pole was along the east coast of Greenland, while our countrymen prefer the route through Davis Strait, along the west coast.

In 1854 he took up his residence at Gotha, having been appointed Director of Justus Perthes's Geographical Institute, the most extensive establishment in the world for the production of maps and charts; this position he held down to his death. That now well-known monthly journal of geography, *Mittheilungen aus Justus Perthes' Geographischer Anstalt*, was founded in 1855, succeeding Berghaus's geographical annual, the "Geographisches Jahrbuch." Petermann assumed the editorship of the new magazine, which quickly reached an eminence unattained by any other periodical of its class. The editor impressed his personality on every page of his magazine, and it is commonly known as *Petermann's Mittheilungen*. It was in the same year, 1855, that he received from the University of Göttingen the degree of Ph. D. Geographical societies throughout the world have enrolled his name in the lists of their honorary membership, and in 1869 the Emperor of Austria conferred on him the order of the Iron Crown, in recognition of his services to arctic exploration. Some years ago he was appointed Professor of Geography in the Polytechnic School at Gotha (*not* in the University of Gotha, as some of the newspapers have it, and that for the sufficient reason that Gotha has no university). He visited the United States in 1876, and was received with fitting honors by the American Geographical Society of New York.

For a few days before his death Petermann suffered from a painful attack of bronchitis, coughing almost continually. At the same time he complained of a headache so intense that the slightest touch of a finger on the forehead caused him an agony of pain. To these physical ills were added domestic troubles of an extremely aggravating kind, and the result was a pitiable state of nervous excitement, amounting almost to frenzy. Life seemed unendurable, and, to terminate his sufferings, the great geographer died by his own hand on September 25th. His father and brother had died in the same manner.

CORRESPONDENCE.

CURIOUS MOUNDS IN CALIFORNIA.

To the Editor of the Popular Science Monthly.

On the stage-road from Mariposa to Merced—a portion of the Yosemite Valley route—for a distance of twenty miles, the surface of the ground, as far as the eye can see, is singularly characterized.

Circular elevations, like mammæ, about two feet high and twenty feet in diameter, are divided by shallow ditches, or swales, about ten feet wide. These mounds are surprisingly symmetrical, and occupy the whole surface. Where the rising ground meets the sky, the outline is regularly scalloped. The freshets have in some places cut through to the depth of three feet, leaving the vertical section exposed to view.

All the stones contained in the mounds are rounded, and in size are from half an inch to four inches in diameter. None larger were seen. The bottoms of the dry water-courses are paved with these round stones to a considerable depth, the largest on top. For six inches in depth of the surface of the mounds the soil is free of stones; below that, the stones are distributed without much regard to size, the spectator being impressed with the apparent fact that the larger ones are nearer the surface.

Rising ground equally with level surface is covered by these mammæ. In rare cases are two mounds thrown together, so as to interfere with the generally symmetrical arrangement. A plausible explanation of the cause of this phenomenon occurred to me: After the surface had been smoothed, and the large elevations rounded, by the moving glacier, the ice-mass became stationary from diminished thickness. The larger stones on the surface would melt through, forming funnel-shaped cavities, into which the water on the surface of the glacier would pour and run out at the bottom, leaving the accompanying dirt and gravel in a heap. But this theory requires that the stones causing the funnel-shaped cavities should be distributed on the surface of the glacier at uniform distances of twenty-five feet from each other, which supposition is inadmissible.

I am constrained to ask for a proper interpretation of the origin of this notable arrangement. S. H. Mead.

Davenport, Iowa, *July* 11, 1878.

MUTILATIONS AND HEREDITY.

To the Editor of the Popular Science Monthly.

In January, 1875, I had a tortoise-shell cat that lost her left fore-paw, as I suppose, in a steel trap. About ten weeks after this accident she had a litter of kittens, and, one being a tortoise-shell, it was saved. The first cat lived about a year. In addition to her limping around on three feet, she had a peculiar habit of holding up the lame foot against her breast, as though she was nursing it, and would frequently come and touch me with it, looking up at me with a pitiful expression on her face. Last spring I obtained a tortoise-shell kitten, a granddaughter of the lame one and a daughter of the cat that was born after the foot was hurt. Now, this kitten has the habit of standing almost constantly on three feet, holding the left one from the ground (sometimes, but not often, she holds up the right one), and she frequently holds it to her breast, as though she were nursing it, in exact imitation of her grandmother, the lame one. She also has the habit of coming up and touching me with her paw, putting on the pitiful expression of countenance that was observed on the face of her ancestor. J. D. A.

Cromwell, Connecticut, *October* 21, 1878.

DOES THE MICROPHONE MAGNIFY SOUND?

To the Editor of the Popular Science Monthly.

Sir: The account of the actual accomplishments of the microphone, in the way of magnifying faint sounds, as communicated to the Royal Society in May last, was so astonishing that every one was led to believe a scientific discovery of immense value had been given to the world, containing *in embryo* practical applications of unbounded extent.

Not the least remarkable feature of this discovery was the extreme simplicity of the apparatus, thereby enabling the merest *dilettante* to repeat the experiments detailed in Prof. Hughes's paper; and I doubt not that a number of experimenters have expended a good deal of time and patience in endeavoring to develop these embryonic possibilities.

It is for the purpose of eliciting the candid opinion of such workers, who may have been more successful than I, that I am induced, through the medium of your valuable journal (while avoiding theoretical considerations which have been exhaustively discussed), to state very briefly the conclusions that I have arrived at after a careful investigation with microphones of varied form:

1. *The microphone does not magnify*

sound, and we cannot expect it, "when further developed by study, to do for us, with regard to faint sounds, what the microscope does with matter too small for human vision."

We cannot correctly regard the sound heard in the telephone receiver as "a magnified image" of the original vibrations; for, while the fundamental tone is reproduced with considerable accuracy, the harmonies or overtones, giving the *timbre*, or individuality to the sound, are in most cases very imperfectly rendered.

2. If the ear is placed in as favorable a position to hear the original faint vibrations (which jar the delicately-poised piece of carbon) as it is when listening to the telephone, it will be found that the increased volume of sound issuing from the diaphragm of the receiver is more imaginary than real.

For these, and other reasons, the writer is of the opinion that the probable future value of this discovery has been greatly exaggerated, and that it is likely to prove an addition to the rather plentiful crop of scientific green fruit which fails to ripen into the full perfection so enthusiastically predicted by the luxuriance of the blossoms.

Respectfully yours,

A. E. Outerbridge, Jr.,
Assay Laboratory U. S. Mint, Philadelphia.

EDITOR'S TABLE.

ELECTRIC ILLUMINATION.

NOTHING is more natural than that there should be great expectations in the non-scientific mind in regard to what electricity is destined to do for the world in future—expectations which, on the one hand, are grounded in reason, and, on the other, are liable to the most extravagant exaggeration. The marvelous things already accomplished by means of this mysterious agent, as made familiar in the electro-chemical industries, the telegraph, telephone, and electrical illumination, have a tendency, of course, to prepare the mind to look for further unusual and astonishing results. Just now a revolution in illumination is widely anticipated, by which the common illuminants will be superseded in the daily life of the people, through improvements in the electrical light. The probability of this important result is greatly increased, and is, indeed, supposed to have become a certainty, because electrical illumination is already an established fact on a large scale, it having been used in light-houses for years, and successfully introduced into factories, depots, theatres, and other places where large spaces are to be illuminated. So much—the main thing, and apparently everything—being actually gained as a fact of experience, the carrying out of the invention into minor details is taken as a foregone conclusion. In this state of the public mind the announcement of Mr. Edison—the foremost inventive genius of the age—that he had actually solved the problem which would make electric illumination available for common household uses, was generally accepted as a matter of course, and sent a tremor through the gas-stocks of the world. Nevertheless, the desideratum has not yet been reached, and, for aught that actually appears, we are no nearer this important consummation than we were twenty years ago.

It may be well to remind the sanguine believers in this unquestionably most desirable improvement, of the analogous excitement there was, some thirty or forty years ago, in regard to electricity as a motive power. A new source of mechanical energy had been discovered in electro-magnetism, which was developed by appropriate machinery, so as to be capable of doing all kinds of work. There was the accomplished fact, and buzz-saws were driven through two-inch planks, before astonished audiences, merely by batteries in the cellar, connected with the working-machine by conducting wires. The steam-engine was threatened, and we seemed to be on the eve of a new epoch in the use of motive powers.

When scientific men shook their heads and said it would not do—that there were limits in the case which forbade the expected progress, and that zinc burned in batteries could not compete with coal burned under the boiler—the replies were ready. First, did not Dr. Lardner say that steam-navigation across the Atlantic was impracticable? Second, was there any limit to that power of which the lightning-flash was an example? Third, if the electro-magnetic engine was weak, was it not also new, and who would presume to put restrictions upon man's inventive genius, especially when the main thing was already achieved, and nothing remained but to work out the minor improvements? The new motor, however, could not be made to work, and so hopes were crushed, investments lost, and the excitement died away.

The difficulty with the electric light, which has hitherto defied resolution, notwithstanding the efforts of experimenters for a generation, is that it can only be realized under an intensity of action that becomes far too expensive for common use, where only a small amount of illumination is required. A brilliant light can be got from the electric current by the incandescence of carbon or metallic particles, which will flood great spaces with a vivid illumination much cheaper than can be done in any other way, but nobody has yet been able to divide and distribute this intense light so as to utilize it in small amounts wherever wanted, at a cost that can compete with the ordinary sources of illumination. A well-informed writer in a late issue of the New York *Sun* gives the following instructive presentation of the present aspect of the subject:

"I judge that the panic in gas-stocks, which has been produced in great part by the broad claims of Mr. Edison to the discovery of a practicable method of subdividing the electric light, is, to say the least, premature. Mr. Edison is now experimenting with his light, and at latest accounts had not solved all the problems involved. The field in which he is laboring is an entirely new one to him, as the science of magneto- or dynamo-electricity is far different from that of telegraphy or electro-magnetism. There are problems involved, especially in the subdivision of the light, which are far greater than any embodied in any previous invention or improvement of Mr. Edison. The scientific world has been laboring at it almost constantly since King's invention in 1848. In 1858 M. Jobart, of Paris, made some very startling claims, which were almost exactly the same as those made by Edison, but continued experiment exposed their fallacy.

"The principal difficulty to be overcome is the lack of economy in any method of producing light by electricity, except by the voltaic arc between carbon-points, and as Mr. Edison disclaims this method, and limits himself to the plan of incandescence, he will find his path beset with difficulties in this direction. This is shown by the well-known fact that an electrical current of a given strength will yield about ten times as much light when used to produce the voltaic arc between carbon-points as it could by being passed through a piece of platinum, so as to raise it to a white heat and give the light. In some experiments recently made in Paris by M. Fontaine, it was found that a powerful battery of forty-eight elements would produce in one lamp a light by incandescence equal to forty burners; but that, when the same current was used in two lamps, the light in each was only three to five burners, and, when divided between three lamps, only one-quarter burner in each. Further subdivision resulted in a total extinction of the light. A similar result was reached whether the lamps were placed in series in the same circuit or in derived circuits. In using a dynamo-electric machine in place of a battery as the source of the electricity, the same difficulty would present itself, with this additional one, that whereas the electro-motive force of a battery remains constant under all changes of resistance, that of a machine does not, but decreases as the resistance increases.

"The writer has thoroughly investigated the subject of electric light as an economical subtitute for gas, and is entirely familiar with all that has been accomplished here or abroad in this direction. Abroad, by means of the Gramme machine and the Jablochkoff candle, sixteen lights of 700-candle power each are produced from one machine, ab-

sorbing sixteen-horse power. The candles cost sixteen cents each, and burn an hour and a half. Estimates of its cost vary from one-half to three times the cost of gas. In this country the field is occupied by several kinds of apparatus. At the American Institute Fair are a number of Wallace machines, furnishing in all nineteen lights, scattered through the main building. Inquiry from the engineer who cares for the engine driving these machines develops the fact that not less than sixty-horse power is consumed for these nineteen lights. In the machinery halls four lights are used, furnished by a Brush machine absorbing seven-horse power. These are much steadier and pleasanter to the eye than those in the main building. The makers of the Brush machine claim that, with a larger machine, absorbing twelve-horse power, they can produce fifteen to twenty lights of 2,000-candle power each, thus considerably improving upon the French system.

"Unless Mr. Edison can substantiate his claims, and produce better results than are given above—and there is not the slightest evidence that he has actually done even as much—the conclusion clearly reached is this: that, for the lighting of dwellings and all places where twenty or thirty or perhaps forty gas-burners suffice, gas will hold its own and still be the most economical light."

Upon the reception of the news in England of what Mr. Edison had done and proposed to do, there was perturbation in gas-stocks, and the editor of *Nature* writes as follows about it:

"Although a student of science will have little difficulty in associating the results promised with the discovery of perpetual motion, it is quite probable that Mr. Edison has actually succeeded in doing what he states he has done in his telegram: 'I have just solved the problem of the subdivision of the electric light indefinitely.' What we wish to point out is, that it is one thing to do this and another thing to produce an electric light for ordinary house and street use. Once put the molecules of solid carbon in motion, and, just because a solid is in question, the light must be excessive and the expenditure of energy must be considerable.

"While it is easy to believe that the future may produce a means of illumination midway between the electric light and gas, it is equally easy to see that the thing is impossible without great waste, and therefore cost, with dynamo-electric machines and carbon-poles. So long as carbon is employed we shall have much light which, perhaps, can be increased and steadied if various gases and pressures are tried. But streets and rooms full of such suns as these would be unbearable unless we sacrifice much of the light after we have got it. Split up the current in the manner so cheerfully described by the New York paper, and the carbon will refuse to flow altogether, if an engine of 5,000,000 horse-power be employed instead of the modest one of 500 which is to light the south part of the island. If Mr. Edison has succeeded in replacing carbon he may have turned the flank of the difficulty to a certain extent.

"Gas companies may well begin to feel uneasy at the general attention which is being drawn to the electric light as a substitute for gas *if they are prepared to let things alone*. That in one form or another it is likely to be partially adopted in all large cities and at extensive public works seems most likely. It will be one of the lights of the future, but not to the excluding or superseding of gaslight.

"Our own columns have repeatedly borne testimony to the success which has attended its introduction into Paris, where it is to be met with at almost every corner, and at one or more of the railway-stations. The general testimony of those who are unprejudiced is, that at least for wide streets, squares, and open places, its lighting effect is all that could be desired. Every Londoner is familiar with the effect of the display which the enterprising Mr. Hollingshead has placed in front of the Gaiety Theatre, and the glowing contrast presented to the miserable yellow flames of the neighboring street-lamps; but this contrast exists because the gas is bad and dear. Mr. Hollingshead, in a letter to the *Daily News*, corrects the view of the gas companies, that the electric light must necessarily cost more to produce than gas. His own display, necessarily wasteful, costs four-fifths what gas would, and he is probably correct in saying that with proper management it need not cost more than one-half. Moreover, in yesterday's *Times*, Mr. E. J. Reed refers to the case of M. E. Manchon, a large manufacturer at Rouen, who had gone to considerable expense to alter his premises to suit the electric light, and who, even with hired engine-power, finds that there is an annual saving of 22.6 per cent. over gas, with infinitely better light and a wholesome atmosphere. Mr. Reed is of opinion that, even if the electric light cost more than gas, its advantages

are so great that, for the lighting of public places, museums, art-galleries, manufactories, etc., he would advocate its general introduction. Even Madrid, one of the most backward cities in Europe, has introduced the light, one great benefit of which, especially in theatres and other much-frequented places, is that the heat generated and the contamination of the air are greatly less than in the case of gas.

"Let the directors of gas companies do all they can to improve their gas. They may be certain that it will never cease to be required; a considerable splitting up of the electric current is impossible, while the brilliant light that we shall always get when electricity is employed will gradually so raise the *pitch* of illumination that more gas than ever will be used."

VANDERBILT UNIVERSITY AGAIN.

COMMODORE VANDERBILT built wiser than he knew in rearing a university at Nashville for the benefit of the Tennessee Methodists, as it is obvious they stand in sore need of education. The Tennessee Conference, meeting in Clarksville in the middle of October, went into the question of education through the report of a special committee, which may thus fairly be taken as indicating the high-water mark of the intelligence and liberality reached by that denomination, in that State, upon that subject. The result shows that the region is excellent missionary-ground for the schoolmaster. It is hardly to be supposed that the inferior schools will be in advance of the higher institutions; and this interests us in what they have to say regarding the character of their new university. The conference applauds it in unmeasured terms, and calls especial attention to the remarkable intellectual influence exerted upon the nascent Tennessee mind by Commodore Vanderbilt's building. They say, "There is an immense educating power in the surpassing beauty of the grounds, the finished elegance of the building, and all that pertains to it." Of this we do not complain. It is indeed ascribing more educational potency to stocks and stones than has been our wont, and leaves Buckle with his "Aspects of Nature," and Spencer with his "environments," far behind; but the conference might well indulge in a little exaggeration out of compliment to the sagacity of the learned and pious founder of the establishment, which could exert this "immense educating power" even before its doors were opened. And it becomes a serious question whether the authorities of the institution might not better have trusted entirely to this silent tuition of structure and surroundings, and not have undertaken to superadd any influences from within. The educational work of Commodore Vanderbilt's architects and landscape-gardeners, whether slight or "immense," is at all events real, honest, and unperverted, which is a good deal more than can be said of the backward and benighted inculcations that are dispensed by the living vocal teachers. We gave an illustration not long ago of the bigotry and intolerance exhibited by the authorities of Vanderbilt University in abruptly dismissing from his position an able professor of science because he taught the present state of knowledge upon the subject confided to his charge. He reported what Science has to say at the present time concerning the antiquity and history of the ancient races of men, and, as this was supposed to conflict with certain old theological dogmas held dear by the Tennessee Methodists, he was summarily ejected from his professorial chair. The proceeding was evidently in imitation of very obsolete precedents, but it proved highly gratifying to the Tennessee Conference. They say:

"The university has afforded us intense gratification by its recent action. This is the age in which scientific atheism, having divested itself of the habiliments that most adorn and dignify humanity, walks abroad in shameless denudation. The arrogant and impertinent claims of this science, falsely so called, have been so boisterous and per-

sistent that the unthinking masses have been sadly deluded. But our university alone has had the courage to lay its young but vigorous hand upon the mane of untamed speculation and say: 'We will have no more of this. Science we want, no crude, undigested theories for the sons of our patrons. Science we must have, science we intend to have, but we want only science clearly demonstrated, and we have great cause to rejoice in this step, for it deals a blow the force of which scientific atheism will find it exceedingly difficult to break.'"

If any one doubts that there is a crying need of the elementary schoolmaster in Tennessee, the literary quality of this official utterance in behalf of a great university will probably be sufficient to settle the matter. But the passage has a more serious aspect. In the announcement for 1878–'79, the first purpose of Vanderbilt University is stated to be the "protection of the morals" of youth during the period of their pupilage. We respectfully suggest that this protection is equally needed for the clergymen of the Tennessee Conference, who seem to have not even a rudimentary conception of the immorality of falsehood and slander. Dr. Winchell, an eminent geologist and scientific scholar, and also a man of known religious character, who had freely published his views and had been but recently chosen as a member of the faculty of the institution, was displaced from his position because the authorities did not agree with all his views; and the Methodist Conference of the State "rejoices" and expresses its "intense gratification" at this blow dealt at "scientific atheism." Dr. Winchell is thus branded with a false and libelous charge by a body of religious teachers which pretends to commend the university as a protector of morals! It is bad enough for the institution to have to stand the consequences of its bigotry and intolerance in this age of growing liberalization, but it might well have been spared this official defense of the denomination to which it belongs.

HUXLEY ON THE RIGHTS OF AUTHORS.

The unsettled state of copyright legislation and the progress of communistic ideas in relation to literary property give interest to all intelligent discussion of the nature and extent of literary rights. We last month gave the evidence of Prof. Tyndall before the English copyright commission on this subject, and we now follow it by that of Prof. Huxley to the same purpose. The commission had various practical things before it, but it gave thorough attention to the fundamental question of the basis of property in published works, and in this Americans are quite as much interested as the English.

The testimony furnished to our readers was elicited by a systematic attempt so to undermine the rights of authors to their books as substantially to break them down. Several able men connected with the copyright commission, either as members of it or as witnesses before it, took the ground that literary property is not like other property, and differs from it in such a manner that Government may interfere to regulate it in a way that amounts to the subversion of it. They say that, as long as an author keeps his book to himself, he owns it; but when he publishes it he parts with it, he surrenders it, and the public then become its owner, and Government may properly appoint an agent to take charge of it and do with it as the authorities please. Unwilling to push the doctrine to the logical extreme of barefaced, downright communism, by stripping the author clean of his property, these parties maintained that government should merely enter into its possession and manage it for him, allowing him such fraction of the profits as it pleased. In lieu of the existing copyright, by which an author makes such a bargain with the publisher as suits both parties, they proposed what is called a "royalty" system, by which anybody who pleases

may print an author's work, by paying him a small percentage, to be determined by the politicians. That department of Government in England which is specially charged with the administration of copyrights is the Board of Trade, and its secretary, Mr. T. H. Farrer, was a member of the commission, and came forward as the chief champion of the royalty scheme. He took the ground that the existing copyright is a monopoly which it is for the interest of society to destroy, and that the royalty system is called for by the principles of free trade. His main coadjutors in managing the case were Sir Henry Drummond Wolff and Sir Louis Mallet, whose position on the subject of copyright was commented upon in the September MONTHLY. It is a credit to the authorities by whom the commission was constituted, that it was made so broad as to bring out the opponents of copyright in all their strength, and give them every chance to make the best case possible; and that their report embodied sound and conservative recommendations is no doubt largely owing to the ability of such testimony as that herewith published from Prof. Huxley. We shall next month give the interesting evidence of Herbert Spencer before the commission.

LITERARY NOTICES.

ALL AROUND THE HOUSE; OR, HOW TO MAKE HOMES HAPPY. By Mrs. H. W. BEECHER. New York: D. Appleton & Co. Pp. 461. Price, $1.50.

MRS. BEECHER'S new book, as its title happily imports, is devoted to the general interests of the household, and not to any one of its specialties. It is a result of the writer's observation and experience, which have been very considerable, and it may be said to correspond to those important books put forth by physicians of large opportunities under the title of "Practice;" so that, as we have Fergusson's "Practice of Surgery," we may be also said to have Mrs. Beecher's "Domestic Practice." She speaks as a working housekeeper who has had varied trial in the administration of home affairs, and her book is full of useful instruction and wise common-sense, which cannot fail to be valuable to those of her sex who are entering upon the duties and responsibilities of family management, and who have any solicitude about doing their work well. We are glad to see that Mrs. Beecher is thoroughly imbued with the true spirit of her subject. She has an elevated ideal of what a home should be; she understands that it cannot be realized without effort, capacity, and preparation, and keenly realizes how little there is done in any thorough or comprehensive way to qualify woman for intelligent or efficient activity in the domestic sphere.

It is certainly a painful reflection that of all the vocations which human beings pursue, in these times of abounding education, none are entered upon so lightly, so carelessly, and with such an utter absence of all adequate qualification, as that of housekeeping, or, as Mrs. Beecher significantly puts it, of "*home-making;*" while, of all the sources of human misery, there is none that yields a more copious measure of wretchedness than the incapacity of woman to take judicious and intelligent charge of household affairs. Everything else must be prepared for, but "home-making" is thought to need no serious preparation. Yet the interests involved are to the last degree varied, complex, and delicate, requiring knowledge, tact, judgment, patience, in fact the highest accomplishments of character. The interests of the office, the counting-house, the school, are simplicity itself compared with those of the household, where diet, clothing, health, the management of children, the control of servants, the duties of hospitality, and the direction of many stubborn elements, demand intellectual and moral attributes of the highest order on the part of the heads of the house, and in a sphere which mainly belongs to woman. And yet this is the one and almost the only department of our social activity for which no preliminary training is provided in any systematic way. The doctor, the lawyer, the clergyman, the miner, the farmer, and even

the accountant, the dentist, and the farrier, each has his college, but where is the college for the "home-maker?" Its necessity is not even perceived. The women are trying with might and main to get into nearly all the colleges that have grown up as preparations for the business of men, and, when they attempt to make one of their own, they are content to imitate as far as possible those of the opposite sex, and never think of demanding institutions in which they may be educated for that line of activity which the great majority of them are destined to pursue.

Mrs. Beecher sees clearly enough that the modern tendency of feminine culture is not in the direction of home improvement, and that whatever is done in the way of help to this end must come in the shape of such occasional contributions as ladies interested in the subject are prompted to offer. She has a chapter on "Home Colleges," which is an excellent idea, as nothing better is yet to be had, while her volume will serve as an admirable text-book for it. The work is well suited where the class-drill is not very severe, being lively and interesting in its manner, as well as useful and instructive in the information it gives. We have read it through with profit, and cordially recommend it to everybody who lives in a house—especially if it has a plurality of occupants. If the hundred pages of receipts at the close (which are no doubt in themselves excellent) were omitted, the volume would make a first-rate reading-book for girls' schools.

United States Commission of Fish and Fisheries. Report for 1875–'76. Washington: Government Printing-Office. Pp. 1079. 1876.

In the popular mind, the sole aim and object of the United States Commission of Fish and Fisheries is to devise and apply measures for the increase of the fish-supply in our lakes, rivers, and smaller streams; but in fact the commission is also charged with the duty of promoting by its researches the interest of the sea-fisheries, and hence it is that much of the present volume—indeed, by far the greater part of it—is taken up with an historical and statistical account of the American whale-fishery. We are inclined to think that it would be best to restrict the labors of the commission to the one department of propagation of food-fishes. The "History of American Whaling" is no doubt very interesting and valuable, but it has no organic relation to the work of the Fish Commission. The commissioner, Prof. Baird, in the report proper, first briefly rehearses the history of the commission; then details the results of the inquiries that have been made into the decrease of the food-fishes; next he reviews the work that has been done in the propagation of food-fishes; and, finally, gives tables showing the number of fish distributed by the commission since the beginning of its work. Then follows Appendix A (780 pages), on the "American Whale-Fishery." Appendix B, "The Inland Fisheries," comprises reports on "The Fisheries of Chicago and Vicinity," on "The Salmon-Fisheries of the Columbia," and "Notes on some Fishes of the Delaware." There are five papers in Appendix C, treating of the carp, the shad, the Schoodic salmon, salmon-breeding in the McCloud River, and the exportation of fishes and hatching apparatus to various foreign countries.

The Life of George Combe. By Charles Gibbon. London: Macmillan & Co. 2 vols. Pp. 739. Price, $8.

It may be thought that an elaborate two-volume biography, issued twenty years after the death of its subject, whose chief claim to be remembered is the close association of his name with a science which is now generally considered as belonging to the past, must rank as a not very judicious literary venture. No doubt a smaller and more inexpensive work would have had a wider sale, yet it is better that the work should have been done just as it has been done. While merely because he was an eminent phrenologist it would not have been worth while to write Combe's life at all, yet as the author of the "Constitution of Man," and as the representative of a transition period in knowledge and education, and as giving us an account of a very interesting character, the biography deserved to be fully written out. That Combe regarded phrenology as the key to all knowledge, that he devoted himself to it with great assiduity, and applied it everywhere as a sufficient

philosophy of human nature, are by no means the real grounds on which he is entitled to be remembered. Phrenology represented a mere point of view from which humanity was to be studied, and that *point of view* was the true one, and a great advance on all previous systems. Phrenology was the rude means of first bringing mental phenomena into relation with organization, in the popular thought. It was almost inevitable that the first theories of this relation should be deficient and erroneous; but, the attitude taken being correct, valuable results flowed from it. It is on account of his views and reformatory labors regarding education, the treatment of the insane, the true principles of prison discipline, and the emancipation of the masses from social and religious prejudices, that Mr. Combe deserves to be gratefully and honorably remembered, and in this respect his biography is of living and permanent interest.

Deterioration and Race Education; with Practical Applications to the Condition of the People and Industry. By Samuel Royce. Boston: Lee & Shepard. Pp. 585. Price, $2.50.

We noticed this instructive work upon its first appearance last year, and are glad to see that it has gone to a second edition, as it contains a great deal of information, bearing upon the subject of education, that cannot be found compiled and digested elsewhere. Mr. Royce views the subject in its broadest aspects, laying great stress upon those forces in society which lead to pauperism and physical, mental, and moral degeneracy, and it is as a corrective of these evil tendencies that he chiefly regards the subject of education. The fundamental idea of his work, illustrated and enforced by numerous facts and copious discussion, is that the great deficiency in our system of mental cultivation is the non-recognition of the element of industry. In the new edition of the book he has added nearly one hundred pages, designed to give increasing effect to this aspect of his general argument. In the first place he demands that education shall include learning to work or an actual preparation for industrial occupations. He appreciates and favors the Kindergarten as the first step in this direction, to be followed up by developing schools and technical institutions to teach the practice as well as the elementary principles of various mechanical trades. He gives an interesting account of several industrial schools and manual institutes, chiefly in New England, which have for their object the training of the young in the skillful and intelligent exercise of hand-labor. Mr. Royce points out the vicious and lamentable influence of the existing system of education, in disqualifying the young for entering upon industrial occupations, by presenting false ideas of life through the excessive and one-sided influence of literature and books alone. It is not the worst, he thinks, that working-studies are ignored, but that in our existing schools there arises a prejudice against manual labor, a contempt of it, and an ambition to get a living by head-work in the practice of the professions. Thousands upon thousands who can never enter the professions, and who have not intellectual faculty enough to win success in life by pure intellectual labor, are nevertheless set upon this track, and unfitted for the honest and efficient pursuit of industrial avocations. Want of space prevents our giving several important quotations from this part of Mr. Royce's book, which readers specially interested in the subject will find it useful to procure.

Superstition in All Ages. By John Meslier. Translated from the French by Miss Anna Knoop. New York: Liberal Publishing Co., 141 Eighth Street. Pp. 339. Price, $1.50.

The author of this curious book was born in 1678, in the French village of Mazerny, and died in 1733, at the age of fifty-five. He has, therefore, been dead nearly one hundred and fifty years; and, although his name is not to be found in any of our common cyclopædias, his book, the only one that he ever wrote, is now first translated into English, and is published in the United States.

Meslier was a Roman Catholic priest, and was for thirty years curate of Entrepigny in Champagne. There is a brief sketch of his life by Voltaire prefixed to the volume, from which we gather that he was a quiet, studious man, of a philosophic turn of mind, who at the seminary devoted

himself to the system of Descartes. He is said to have been strictly just and warmly benevolent, attending regularly and faithfully to his clerical duties, and at the end of each year giving what remained of his salary to the poor of his parish.

The following incident is recorded as illustrative of his character: "The lord of his village, M. de Touilly, having ill-treated some peasants, he refused to pray for him in his service. M. de Mailly, Archbishop of Rheims, before whom the case was brought, condemned him. But, the Sunday which followed this decision, the Abbot Meslier stood in his pulpit and complained of the sentence of the cardinal. 'This is,' said he, 'the general fate of the poor country priest; the archbishops, who are great lords, scorn them, and do not listen to them. Therefore, let us pray for the lord of this place. We will pray for Antoine de Touilly, that he may be converted, and granted the grace that he may not wrong the poor and despoil the orphans.' His lordship, who was present at this mortifying supplication, brought more complaints before the same archbishop, who ordered the curate Meslier to come to Douchey, where he ill-treated him with abusive language."

So there was nothing remarkable or unusual about the outward career of this country preacher that was not suitable to be immediately buried in oblivion. But he had been long and quietly at work in a way that was calculated to give interest and notoriety to his name after he had finally left the scene of his labors, where he died in the odor of sanctity. Meslier, it must be said, to the great scandal of his name, did not believe in the theology that he preached. But he lived in times in which men were not very powerfully solicited to express their independent opinions, and, as Meslier said he did not want to be burned alive on account of what he thought, he prudently followed the example of Copernicus and postponed publishing his real views till after he was out of the way. When Meslier was gone, there was found in his house a manuscript volume entitled "Common-Sense," written in his hand, and addressed as "My Testament", to his parishioners. The book was printed, and went through various editions in the eighteenth century, and it is this which is now revised and translated by Miss Knoop. Of its quality the reader can judge from a remark of Voltaire in a letter to D'Alembert, which is as follows: "They have printed in Holland the Testament of Jean Meslier; I trembled with horror in reading it. The testimony of a priest who, in dying, asks God's pardon for having taught Christianity, must be a great weight in the balance of liberals. I will send you a volume of this testament of the anti-Christ, because you desire to refute it."

We have not read this book, and are, therefore, unable to form a critical judgment of it; but Mr. James Parton writes to its translator concerning it as follows: "The work of the honest pastor, Jean Meslier, is the most curious and the most powerful thing of the kind which the last century produced. Thomas Paine's 'Age of Reason' is mere milk-and-water to it, and Voltaire's 'Philosophical Dictionary' is a basket of champagne compared with a cask of fourth-proof brandy. Paine and Voltaire had reserves, but Jean Meslier had none. He keeps nothing back; and yet, after all, the wonder is not that there should have been one priest who left that testimony at his death, but that all priests do not. True, there is a great deal more to be said about religion, which I believe to be an eternal necessity of human nature, but no man has uttered the negative side of the matter with so much candor and completeness as Jean Meslier. You have done a virtuous and humane act in translating his book so well."

THE AMERICAN ANTIQUARIAN: A Quarterly Journal devoted to early American History, Ethnology, and Archæology. Edited by Rev. STEPHEN D. PEET, Unionville, Ohio. Cleveland, Ohio: Published by Brooks, Schinkel & Co. Price, $2 a year, or 50 cents a number.

THE rapid growth of the biological sciences, initiated by the publication of the "Origin of Species" nearly twenty years ago, has brought into especial prominence the great questions of the origin, antiquity, and development of man; and from subjects of theological speculation has transformed them into well-recognized problems of physical science. All the various lines

of biological inquiry converge in this direction; and, as pointed out by Prof. Huxley in his address on "The Progress of Anthropology," published in the October number of this journal, that science has already gained a well-established place, counts among its numerous workers a large number of eminent men, and promises to remain, for many years to come, the chief centre of scientific interest in all countries where science is cultivated.

Up to within a few years most of the work in this department has been done abroad, and the Anthropological Societies of Paris, London, and Berlin, each with its special organ for making known the fruits of research, and with a large and distinguished membership, show the wise provisions that have been made for the prosecution of future investigations.

Although commonly spoken of as the "New World," it is becoming daily more apparent that this continent has had a past that is full of interest for the archæologist and ethnologist, and out of which much is yet to be gathered that will throw light on the interesting problems involved. American investigators are already numerous, and the publication before us meets an important want, in supplying an authoritative medium for the announcement of discoveries, the discussion of new views, and the presentation of the results of American research. The broad ground it is intended to cover is thus stated in the prospectus:

"The Early History, Exploration, Discoveries, and Settlement of the different portions of the Continent.

"The Native Races, their Physical and Mental Traits, Social Organizations and Tribal Distinctions; their Religious Customs, Beliefs, and Traditions, as well as their earlier and later Migrations and changes.

"The Antiquities of America, especially the Prehistoric Relics and Remains, or any evidences as to Ancient Earthworks and Structures, Inscriptions, Hieroglyphics, Signs, and Symbols.

"Prehistoric Man, his Origin, Antiquity, Geological Position, and Physical Structure.

"*The Antiquarian* will also treat of subjects of a more general character, such as The Descent of Man, The Rise of Society, The Origin of Writing, The Growth of Language, The History of Architecture, The Evolution of Ornament, and Ceremonial Observances, Comparative Religions, Serpent-Worship and Religious Symbols, Man and the Mastodon, Man and Animals, Earth and Man, and many other topics which are connected with the Science of Anthropology, especially as they are viewed by the antiquarian.

"Besides these topics especial arrangements have been made by which articles will be contributed upon Archæological Relics, upon Aboriginal Languages and Dialects, and upon the Traditions of this Continent compared with those of other lands.

"The Investigations made by different Historical and Scientific Societies, as well as the Results of all Explorations and Discoveries, will also be reported as far as possible.

"In the editorial management the assistance of several prominent gentlemen has been secured."

The present number contains nine articles, all of them on topics of interest, and several finely illustrated. There is also a valuable editorial department, made up of contributions from several distinguished writers besides the editor-in-chief. The magazine is a credit to American science, and deserves to be well sustained.

The Parks and Gardens of Paris. Considered in Relation to the Wants of other Cities, and of Public and Private Gardens. By W. Robinson, F. L. S. Second edition, revised. Illustrated. London: Macmillan & Co. Pp. 548. Price, $7.50.

The object of this work is to acquaint the reader with those important points of general public gardening, and of fruit and vegetable culture, in which France is in advance of other countries. The author, who has traveled extensively and given prolonged and careful attention to the subjects treated, looks upon English agriculture and rural affairs in general as far before those of France, yet in many important matters he shows that there is much to be learned of the French. The first half of the book is devoted to the parks and gardens in and about Paris, and to the squares, avenues, boulevards, and other improvements, of new Paris. In his criticisms, the aim of the author has been "not only to record and illustrate what is good in them, but also to point out what is harmful." While he finds much to learn and much to admire in their public grounds, yet of the cemeteries he says that "their best aspects are painful to any one who knows what is possible, or what has already been accomplished in the formation of decent burial-grounds near large cities." After a most

revolting account of the mode of burial of the poor in Père-Lachaise, the statement follows that "the Americans are the only people who bury their dead decently and beautifully—that is, so far as the present mode of sepulture will allow them. For beauty, extent, careful planting, picturesque views and keeping, the garden cemeteries formed within the past generation near all the principal American cities are a great advance upon anything of the kind in Europe."

In horticulture the questions discussed are such as the skillful cultivation of hardy fruit-trees, which has made fruit so good and plentiful in France, and has led to its large exportation; the remarkable culture of asparagus, by which it is grown so abundantly that for many weeks in the spring it is an article of popular consumption; Parisian mushroom-culture; lettuce-growing in winter and spring in the suburbs of Paris, by a method so successful that they are able to supply their own market and that of many other cities. When these tender lettuces are eaten in winter, in England, they are supposed to come from some soft southern climate, while in fact they grow in a climate as harsh as that of England. The various processes by which these results are gained are minutely described, and every page of the volume is full of interest and instruction. There are 538 superb illustrations, many of which, in the chapters upon the parks and gardens, are full-page views of scenery and architecture.

Tribes of California. By Stephen Powers. Washington: Government Printing-Office. Pp. 635. 1877.

The aborigines of California differ from the Atlantic tribes in sundry essential particulars, but most of all, perhaps, in their unwarlike temper. They are a humble and lowly race, one of the lowest on earth; yet the story of their lives might convey to more favored races many a lesson of thrift, contentment, and even of manly virtue. The author has lived among these Indians for three years, studying their manners and customs with intelligent sympathy, and his book is full of most curious information concerning their social, political, and religious usages. We must not omit to add that the work evinces in Mr. Power no mean degree of literary skill; hence it is "as interesting as a romance." It is illustrated with a number of excellent plates. There is an appendix on "Linguistics," by Major Powell (of whose "Contributions to North American Ethnology" this work forms Vol. III.), containing comparative vocabularies of the various dialects spoken by the native races of California. The large map which accompanies the volume shows the distribution of the different tribes throughout the State.

American Colleges: Their Students and Work. By Charles H. Thwing. G. P. Putnam's Sons. Pp. 159. Price, $1.

This is a carefully-digested and useful little volume, giving a great deal of information in relation to American collegiate institutions. It treats of "Expenses," "Morals," "Religion," "Societies," "Athletics," "College Journalism," "Fellowships," "Chairs of a College," and "Rank in College as a Test of Distinction."

A Dictionary of Music and Musicians. Edited by George Grove. Part IV. Macmillan & Co. Price, $1.25.

This number runs from "Concert-Spirituel" to "Ferrara," and, like the former numbers, is full of musical science, art, erudition, and biography. The work improves with every number.

PUBLICATIONS RECEIVED.

Sanitary Examination of Water, Air, and Food. By Dr. Cornelius B. Fox. Philadelphia: Lindsay & Blakiston. 1878. Pp. 528.

Life in other Worlds. By Dr. Adam Miller. Chicago: Fox, Cole & Co. 1878. Pp. 282. $1.50.

The Old House altered. By George C. Mason. New York: Putnam's Sons. 1878. Pp. 179. $2.50.

The Proportions of the Steam-Engine. By William D. Marks. Philadelphia: J. B. Lippincott & Co. 1879. Pp. 161.

How to parse. By Rev. Edwin A. Abbott. Boston: Roberts Brothers. 1878. Pp. 374. $1.

Introductory Chemical Practice. By G. C. Caldwell and A. A. Breneman. New York: Van Nostrand. 1878. Pp. 170. $1.50.

Zoölogy of the Vertebrate Animals. By Dr. Alexander Macalister. New York: Holt & Co. 1878. Pp. 146. 60 cents.

Outlines of Ontological Science. By H. N. Day. New York: Putnam's Sons. 1878. Pp. 452. $1.75.

The Blessed Bees. By J. Allen. Pp. 169. $1.

Flower Painting. Same publishers. Pp. 46. 50 cents.

A New Exposition of the Leading Facts of Geology. By Gideon Frost. New York. 1869. Pp. 80.

American Quarterly Microscopical Journal. Edited by Romeyn Hitchcock. Vol. I., No. 1. New York: Hitchcock & Wall. 1878. Pp. 98. $3 per year.

The Brain and Nervous System. By Dr. J. C. Reeve. Dayton, Ohio: *Democrat* print. 1878. Pp. 32.

Maximum Stresses of Framed Bridges. By William Cain. Hand-book of the Electro-Magnetic Telegraph. By A. E. Loring. New York: Van Nostrand. 1878. Pp. 192. 50 cents each.

Report of the Engineer of the Philadelphia Water Department. Philadelphia: Markley & Son print. 1878. Pp. 96, with Charts.

Ventral Fins of Ganoids. By James K. Thacher. From "Transactions of Connecticut Academy." Pp. 10, with Plates.

Life and Scientific Work of Charles Frederick Hartt. By Richard Rathbun. From "Proceedings of the Boston Society of Natural History. 1878." Pp. 27.

The Cambridge Boiler Explosion. By J. R. Robinson. Boston: A. Williams & Co. 1878. Pp. 40.

The Indian Question. By General Pope. Pp. 31.

An Animated Molecule. By Dr. Daniel Clark. Utica: E. H. Roberts & Co. print. 1878. Pp. 42.

Hygiene of the Eyes. By Dr. F. Park Lewis. Pp. 8.

Artificial Mounds of Northeastern Iowa. By W. J. McGee. From *American Journal of Science*. Pp. 7.

The Food of Illinois Fishes. By S. A. Forbes. From "Bulletin of Illinois State Laboratory of Natural History." Pp. 16.

Median and Paired Fins. By J. K. Thacher. From "Transactions of Connecticut Academy." 1877. Pp. 30, with numerous Plates.

Recording Articulate Vibrations. By E. W. Blake, Jr. From *American Journal of Science*. Pp. 6.

The Religion of Philosophy. By W. H. Boughton. Pp. 19.

On Repulsion resulting from Radiation. By William Crookes, F. R. S. From "Transactions of the Royal Society." 1878. Pp. 76.

An Elementary Course of Geometrical Drawing. By George L. Vose. Boston: Lee & Shepard. 1878. Thirty-eight Plates. $5.

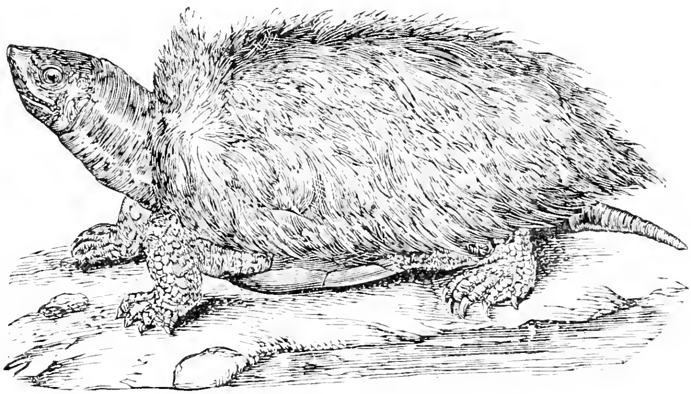
POPULAR MISCELLANY.

A Hairy Water-Tortoise.—The following interesting bit of natural history is from the pen of Mr. Frank Buckland, in *Land and Water*: "Through the kindness of Mr. White, son of the late lord-mayor, I am enabled to give a representation of a most interesting little creature which he himself brought from China. It is a terrapin, or water-tortoise, which apparently has hairs growing out from its back. When it first arrived it seemed very unwell, and I do not wonder, for the poor little thing had not had anything to eat for some months. Knowing it was very intolerant of cold, I placed it in warm water, and kept it in a warm place, and the little thing shortly, to my delight, began to feed from my hand. It will snap at and devour little bits of meat, fish, shrimps, etc. As the little animal swims, the fibre of the vegetable growth hangs away from him so as to give him the appearance of an animated bunch of weeds. His face is very intelligent.

"Among the collection of Chinese and Japanese bronzes, drawings, pottery, etc., I have observed representations of various monsters, and among them those of tortoises with long tails. It now is certain from this specimen, so kindly given me by Mr. White, that the Chinese really have in their aquaria terrapins covered with this remarkable growth. If the hairy terrapins of the Chinese artists be founded on actual living specimens, may it not be possible that other of these well-known monstrosities—such as dragons—may have their origin from traditions, or may be late survivals of such creatures as the plesiosaurus, etc.? I have read somewhere that the Chinese are the direct descendants of Noah, and that when Shem, Ham, and Japheth, went respectively north, south, and west, Noah himself went east, and founded the great Chinese nation. Certain it is that they have traditions of birds and animals totally unknown to the present inhabitants of the earth. I do not know whether the growth upon this terrapin's back has been produced artificially or naturally. It is simply a water-grass, something like the weedy material growing on decaying wood-work and lock-gates of rivers. It is possible that the ingenious Chinese may have some way of doctoring up the living specimens of terrapins, of which I understand considerable numbers exist in the ditches and marshes of China. These Chinese, as we are all aware, are stated to have the art of making the large fresh-water pearl-bearing mussels secrete pearls, and cover over metal images placed within the shells for that purpose. If they can do this with the pearl shell, I do not see that it is impossible for them to make this vegetable material grow upon the back of a tortoise.

"In 1873 Mr. Sandilands kindly gave me

one of these hairy terrapins, and upon that occasion a correspondent, 'A. B.,' kindly sent me the following note: 'In the "Travels of a Pioneer of Commerce in Pigtail and Petticoats," by T. T. Cooper (London, Murray, 1871, page 459), there is a plate of one of these hairy tortoises from the lakes of Ha-su, above Hankow. These curious little animals were about two inches long, and covered on the back with a long confervoid growth resembling hair. The tortoise being a sacred emblem in China, the Chinese make pets of the hairy tortoise, which they keep in basins of water during the summer months, and bury in sand during the winter. A small lake in the province of Kiang-su is famous for these so-called hairy tortoises, and many persons earn a livelihood by the sale of these curious little pets. The figure in Mr. Cooper's book looks like an oval door-mat with a tortoise-head sticking out at one end.'



THE HAIRY WATER-TORTOISE.

"I have been to the British Museum to see if I could find anything like this hairy terrapin, but could not do so. I shall take the liberty of forwarding this article to his Excellency the Chinese embassador, who, I have no doubt, with his usual kindness, will obtain some further information about this great curiosity."

Spider-Architecture.—The snare of the basilica spider would form an interesting object of study for the architect. In it he will find many a difficult problem of constructive science happily solved, and it may be derive useful hints to guide him in the construction of more substantial edifices. As described in the "Proceedings of the Academy of Natural Sciences," of Philadelphia, by Rev. H. C. McCook, who has studied *Epeïra basilica* among the hills of the Colorado River, Texas, the snare of this spider is of composite structure, consisting of a pyramid of web, within which, near its base, is suspended a dome of the same material, and hanging beneath the open bottom of the dome is an horizontal sheet of cobweb. The structure is illustrated in Mr. McCook's paper, and the general effect will be understood if the reader will imagine a pyramidal tent of netting, inclosing a spread umbrella, with a screen of web suspended by cords from the inside of the umbrella and the tips of the ribs. The whole structure is usually suspended from a bush, and thoroughly steadied and its form perfectly preserved by means of silken guys. The meshes of the pyramid are irregular and very open; the sheet under the dome is also of irregular structure, but the dome is constructed of a vast number of radii crossed at regular intervals by concentrics, after the manner of the snare of the common orb-weaving garden-spider. At the bottom of the dome the radii are about one-sixteenth of an inch apart, and the concentrics extend entirely and with equal regularity to the summit, the meshes much resembling those of a fisher's net. The diam-

eter of the dome is from seven to eight inches at the base, and its height is about the same. The inhabitant of this most curious structure is thus described by our author: "The fore-part of the body, cephalothorax, is of a golden-yellow color, bordered and marked with blackish bands. The legs are of a delicate green, having the thighs marked by blackish longitudinal bands, and blackish annuli at the joints. On the back of the abdomen the colors within the blackish marginal lines are as follows: at the base, next the cephalothorax, a snowy white; the middle lobes are a light yellow, the lower lobes and the cruciform figure are a golden yellow. The bands and markings on the side of the abdomen are in the following order from the top, viz., crimson, white, dark green with light-green edges, blackish to dark green, yellow." But in the mind of the araneologist the special interest of the basilica spider is not its architectural skill, not its beautiful markings, but the fact that it seems to form a link between the orb-weaving and the line-weaving spiders.

Manufacture of Sea-Salt in San Francisco.—At Rock Island, in the bay of San Francisco, works have lately been established for reducing salt from sea-water by solar evaporation. The process of evaporating the salt-water is described as follows in the *Engineering and Mining Journal:* "The water is let into a large reservoir at high tide, and thence passed into a series of other reservoirs, until it has traversed a distance of fifteen to twenty miles, in the mean time steadily increasing in strength and dropping its limy impurities. In the fourth reservoir the specific gravity is 16°, and it leaves the seventh when it is 25°. Pure chloride of sodium begins to form when the brine attains this density, and continues to do so until it has attained 29°. During the strengthening of the sea-water from its natural specific gravity of about 1.03 to 25, the sulphate of lime held in solution crystallizes and settles to the bottom. It is not until a specific gravity of 29 is reached that chloride and sulphate of magnesia, bromide of soda, and chloride of potassium, begin to concrete. These being the principal if not the only impurities, with the exception of a little water, the manner of securing pure salt appears very simple. When at 25°, the pickle is run into crystallizing ponds or vats, some of which are simply the earth hollowed for the purpose; others are boarded on the bottom, while a third is made wholly of boards. In these the brine is allowed to remain until it is 28½°, when the salt which has formed in the bottom is shoveled into baskets, loaded on cars, and conveyed to another part of the island nearer the wharf, where it is piled up in great pyramidal-shaped mounds. These remain exposed to the sun and weather for a year, which whitens and purifies the crystals preparatory to grinding."

Atmospheric Electricity and Plant-Growth.—Atmospheric electricity is, according to M. Grandeau, a powerful agent in the process of assimilation in plants. Plants protected from its influence build up fifty to sixty per cent. less of nitrogenous matter than those subject to ordinary conditions; the proportion of ash is higher and of water lower. In the author's experiments different species of growing plants were inclosed within an electric screen consisting of four triangles of iron. The plants experimented upon were maize, tobacco, and wheat—two specimens of each—of which the one was screened from atmospheric electricity, the other not. The results of these experiments agree fully with the discovery made some time ago by Berthelot, that free nitrogen unites with organic matter under the action of electric currents not only from ordinary induction-coils, but even from feeble voltaic batteries. The proportion of nitrogen thus fixed in seven months in paper and dextrine was 1.92 thousandths.

Pure Teas.—The Chinese minister at Washington, Chin-Lan Pin, was lately visited by a delegation representing a firm of tea-importers in Baltimore, who wished to learn his views regarding the importation into this country of pure teas. The minister in his reply said that the various brands of tea sold in America and Europe are unknown to and not used by the tea-consumer in China. They are specially prepared by the Chinese tea-exporters for the foreign market. They are colored by the use of

chemicals; and the process, together with the peculiar methods of fixing up tea for foreign markets, not only renders the plant less palatable and beneficial, but more expensive. The adulteration and coloring of teas for the foreign market, he said, are wholly in consequence of the demand which has existed for such teas; and the minister expressed the opinion that if the Boards of Trade in New York and China would make known the fact that pure teas are not only better but cheaper, it would benefit both producer and consumer. There is, he said, really only one kind of tea-plant, and from this both the green and black teas are produced. The equivalents for the two terms "green" and "black" do not signify to the Chinese the color of the tea, as in America, but have reference to the period of gathering, "green" indicating to them, as in "green corn," not a color, but a state of immaturity.

Prof. Winchell on College Education.—Prof. Alexander Winchell, in a recent address, said that the ratio of college graduates to our population is continually diminishing; this, he held, would not be the case if college education were, under the conditions of modern life, as good a preparation for a successful career as it was in former times. But while the requirements of our time are totally different from those of earlier periods in the history of man, our system of education is still, to all intents and purposes, what it was in mediæval times. Among the deficiencies of our collegiate education, the most serious, according to Prof. Winchell, is ignorance of our national organization, laws, and political history, and of the principles and laws of political life; then, insufficient knowledge of the governments and history of modern European states and of their statesmen. Last, but not least, comes comparative ignorance of the natural sciences and of mechanical and free-hand drawing. Our so-called liberal education embraces but a pitiful amount of the systems of knowledge which are moving the world. Nor are these shortcomings confined only to our colleges and universities. In our elementary schools, at the age when every active power is ready to spring forth and seize the living truth, we try to satisfy with syntax, and a list of names from Siberia. "All children like to see pictures, and to make pictures; but, instead of fostering this useful instinct, a picture on the slate is as horrifying to Miss Nancy or Mr. Petrifact as the name of science is to our mediævalized theologian. When a boy is aching to take a locomotive to pieces, we set him to dissecting a verb. Let him gratify his curiosity; let him entertain himself with chemical reagents; give him means to make a telephone or a steam-engine; allow him to drive nails and a jack-plane; give him a microscope and a geological hammer. With these things he will unite hand-work with head-work in a most fruitful alliance; and when he becomes a man, he may be either a mechanically expert scholar or a scholarly mechanic. As a scholar he will understand affairs and possess the common-sense which will turn every situation to account. As a mechanic he will understand his business, and make a 'boss' who may be trusted without misgiving."

History of an Ant-Community.—Like Sir John Lubbock, the eminent French chemist Berthelot devotes much of his leisure time to studying the ways of ants. He has for years closely observed an ant-hill, which at first presented the form of a little conical hillock, peopled by thousands of inhabitants. The history of this community, as recorded by Berthelot, has a striking resemblance to human history—the same arts of peace and of war, the same distinctions of classes, the same fluctuations of fortune. The ants excel as hunters, as marauders; they have among them skilled architects, thrifty housewives. Division of labor is enforced. There are civilized ants and barbarians. The warriors despise the toil and drudgery of civil life, and they delight in making set raids, taking numbers of prisoners, and reducing them to servitude. While their betters are taking their walks abroad, or carrying on their wars, the slaves care for the young, and attend to the household affairs and economies. It is interesting to observe them while engaged in building. There are superintendents of work, and there are simple workers. Sometimes the latter make mistakes; for instance, suppose they have to build an arch,

they make an error in determining the proper curve. But when the superintendent comes he notices the mistake, pulls down the faulty piece of masonry, and corrects the error.

When M. Berthelot first saw this ant-city it had already been in existence for some years, and was in the high tide of prosperity. Ten years later it sent out a colony, which settled at the foot of a young oak, distant a few metres from the mother-city. This colony, at first weak and occupying but little ground, increased year by year. The war of 1870 for a while interrupted the course of M. Berthelot's researches, but on the return of peace there was a new surprise. The mother-city was now in a state of decline, but the colony was thriving wonderfully. In the old home there were but few births and few fruitful unions; the number of inhabitants had grown less, and the survivors were careless of their dwellings. The colony has now become the principal city, it has sent out a sub-colony which is in a flourishing condition. The old city is compared by M. Berthelot to Babylon, with its thriving neighbor cities of Seleucia and Ctesiphon.

Persian Hair-Dye.—The practice of dyeing the hair is very much in use among the Persians, who mostly employ the plant henna for this purpose. According to Dr. Tholozan, the private physician of the shah, the powdered leaves of the plant are made into a paste with hot water and then applied to the head, the hair, and the nails. This is done in a vapor-bath. This first application lasts an hour and a half to two hours, and then the parts are freely washed in water. The henna gives an orange-red color, very beautiful on a white beard, so that many old men use it. To change the reddish color of hair into a fine, lustrous black, the parts are coated, at the same sitting, with a paste formed of another powder—that from the leaves of a kind of indigo-tree cultivated in Persia. This is called *reng;* it remains applied about two hours. The henna gives different colors according as it acts on white, fair, or dark hair. It alters very quickly in moisture, and loses its properties in long sea-voyages. Experience seems to have proved that it gives suppleness to hair, but it causes it to whiten prematurely. Fair-haired people in Persia always color their hair black, but the black is not so intense as that produced in persons of dark complexion. Skin reddened and blackened with the two pastes soon regains its natural color on being washed with soap and rubbed with the fingers, whereas the dye adheres firmly to the hair, which it penetrates. Reng is sometimes used alone, and gives a blue-violet color.

About Oleomargarine.—Mr. John Michels points out, in the *American Journal of Microscopy*, the differences between butter and oleomargarine as observed with the microscope. Two woodcuts illustrate the paper, the one exhibiting the microscopic appearance of oleomargarine, the other that of butter. In the former substance are seen numerous stellate or feathery crystals, together with globules. In butter none of the crystals are seen, the whole field of the microscope being filled by the globules, with perhaps crystals of common salt. Besides these stellate crystals, Mr. Michels found in all the specimens of oleomargarine examined by him fragments of tissue and muscle, also certain *cells of a very suspicious character.* What these cells may be the author does not assume to decide, but he appears to suppose that they might possibly be the larval forms or eggs of *entozoa.* Some of Mr. Michels's observations on oleomargarine and its suitableness for human food having been called in question, in particular his statement that living *septic organisms* may exist in the artificial butter, he submitted the matter to the Rev. W. H. Dallinger, of Liverpool, a very high authority indeed. Mr. Dallinger's reply is given in full by the author. He writes: "A temperature of 120° [which is the highest temperature employed in the manufacture of oleomargarine] is not by any means seriously, and certainly not permanently, injurious to even the *adult* forms of the putrefactive organisms." Again: "Quite as serious a matter is that of the introduction, through oleomargarine, into the human intestinal tract of eggs of *entozoa.* I have made enough experiments to say that the eggs, for example, of the *nematoda* are practically uninjured by 120° Fahr. This," Mr. Dal-

linger adds, and his warning will carry great weight, "is an important matter, and, although likely to be in practice neglected at first by the public, may *probably impress itself upon them in an unwelcome manner*"—that is, by a serious outbreak of trichinosis, or some other form of parasitic disease.

Cultivating Disease.—The virulence of the yellow fever in Memphis is easy to account for when the sanitary conditions of that city are understood. Two or three years ago we published some mortality statistics concerning this place, which appeared to show that it is exceptionally unhealthy. It would indeed be nothing short of a miracle if Memphis were a healthy city with its highly insanitary surroundings. The situation is thus described in the *Lancet and Clinic*, by Dr. S. H. Collins, a Cincinnati physician, who rendered efficient service in Memphis as a volunteer during the prevalence of the epidemic: "Memphis is situated upon the east bank of the Mississippi, upon a bluff varying from fifteen to fifty feet in height. Upon the crest of this bluff runs Front Street; from this street the ground slopes eastwardly away from the river, so that all rain, surface-gutter washings, slop, and whatever of floatable filth there may be, is drained into the bayou, which winds about through the heart of the city. Across the river the Arkansas shore stretches low and flat, a vast marsh, notorious for its malaria; north and east of Memphis upon the Tennessee side, the land is low and swampy; the soil in and about the city, of clay. The bayou runs through the most thickly-populated parts of Memphis; into this elongated cesspool is collected all the floating filth of a city of 55,000 inhabitants; garbage, the drainings from privy-vaults, gutter and street washings, dead animal matter, all and everything is poured or thrown into this receptacle, there to decay and fester under the broiling sun of that southern climate. Consider it, if possible—ten miles of reeking rottenness! Not a yard of it covered except where crossed by the bridges of the various streets. During a rise of the Mississippi the back-water fills this bayou bank-full, its accumulated filth then soaking into the clay of its banks. When the river falls, the current of the bayou is not of sufficient strength to empty its contents into the river. The streets of the city of Memphis are beyond description filthy, and completely out of repair; the wooden pavement is the one in use, or rather was the pavement originally put down. The streets and yards are heavily shaded—the magnolia being the tree mostly used."

The Movements of Plants.—After much patient study of the phenomena known as heliotropism and the sleeping and awaking of plants, M. Paul Bert, in a memoir addressed to the Paris Academy of Sciences, an abstract of which is published in the *Revue Scientifique*, offers an ingenious theory to account for them. The swelling of the flower or leaf stem just below these organs has long been recognized as the seat of the movements in question, and hence it has been called the "motor-swelling" (*renflement moteur*). The movements are directly produced by changes in the energy with which the *renflement moteur* supports the flower or leaf, and this energy is greatest at night. For a long time the author was baffled in his investigation of the matter constituting the "motor-swelling." Nevertheless, after a protracted series of minute observations, he recognized in the glucose the fundamental cause of the periodic movements. It is known that this substance is formed under the action of solar light, that it is decomposed in darkness, or that it migrates and sometimes accumulates at different points of the plant organism. Now, one of these points is the *renflement moteur*, and it is very plain that its quantity there varies at the different stages of the diurnal life of the plant. Thus the greater part of the phenomenon is due to the storing up and then to the destruction of the glucose, the hydration of which produces the energy of the motor-spring. The same explanation serves to account for heliotropism, another phenomenon due to the action of the highly-refracting rays of the spectrum on glucose or on its hydration. Inasmuch as the action of these rays lessens the tension on that side of the "motor-swelling" on which they fall, the opposite side gains a relative increase of energy, and hence results a certain motion; and, as the sun moves on

its course, the leaf follows, but the reason is always a diminished tension on the illuminated side. This is true of the stalk as well as of the flower. Hence the two phenomena of periodic movement and of heliotropism depend on variations in the quantity of the glucose contained in the point of movement.

Value of the Robin to the Agriculturist.—Like the English sparrow, the "robin" (*Turdus migratorius*) has human enemies and detractors who will not admit that he is of any use whatever to the gardener and fruit-grower; but assert that he prefers to grow fat on stolen cherries and other small fruits, rather than on an insect-diet. But what are the facts? Lieut. D. A. Lyle, U. S. A., reared a robin from the fledgling state to maturity, in the mean time closely studying the bird's preferences in the matter of food, and here is the result of his observations, as communicated to the *American Naturalist*: On being taken from the nest, the young bird was placed in a cage, with plenty of boiled eggs and mashed potatoes and pure water. He would neither eat nor drink, but sat drawn up in the bottom of the cage, giving vent to an occasional chirp. The food was then forced down his throat, and this treatment revived the patient somewhat, but did not give entire satisfaction. He then received raw beefsteak three times a day, with bread and egg at intervals. The effect was striking: the eyes brightened, the chirp became loud and strong, and the bird would hop about briskly. He soon learned to open his mouth for the food. Next he was for three days restricted to a diet of earthworms, of which he would eat his fill, and then retire moodily to a corner, there to remain for about fifteen minutes, till the meal was digested. But, as this food acted as a purgative, it was alternated with beefsteak. The June beetle being then in season, that species of food was tried, and the bird preferred it to anything else. As long as June beetles could be procured, they constituted the sole food of the bird, and he thrived marvelously on it. Every day he consumed forty to fifty of these large beetles. "One morning," writes Lieut. Lyle, "at seven o'clock I gave him fifteen; I returned from the office at twelve, and from that time until sunset I fed him all he could eat. During this time he disposed of seventy-two of the large beetles!" When the June bugs were no longer to be had, cherries were given to the bird. These, when he was hungry, he would eat greedily, but they were speedily rejected when a few coleoptera or a piece of raw steak appeared in sight. The author then makes an estimate of the number of insects probably destroyed *per diem* by the twenty-three pairs of robins occupying the grounds around his residence, taking as the basis of his calculation the performance of his captive robin, and finds that the number would be at least 4,600, or 138,000 per month! Examination of the cherry-trees growing on the grounds showed that only about one cherry in twenty had been injured by the birds—a very low price to pay for their service in exterminating the noxious insects.

Gelatine as a Food-Preservative.—Dr. Campbell Morfit's "gelatine process" for preserving articles of food—as milk, vegetables, fruits, etc.—possesses many advantages which will undoubtedly win for it a very general acceptance. It consists in adding to the substances to be preserved a certain proportion of gelatine, and then drying the mixture till it does not contain over 10 or 12 per cent. of moisture. The mode of applying the process to the preservation of milk is described as follows in *Nature*: One pound of gelatine is dissolved in a gallon of milk at a temperature of 130° to 140° Fahr., and the solution is then allowed to set into a jelly, which is cut into slices and dried. By employing the product of this first operation in place of fresh gelatine for gelatinizing a second gallon of milk, a jelly is obtained in which the milk solids are just doubled in amount. As a gallon of milk contains about 6,400 grains of these solid matters, viz., casein, milk-sugar, milk-fat, and phosphates, their ratio to the gelatine will become as 12,800 to 7,000 after the second operation just described. If, then, the dried *milk jujube*, as it may be now called, be again and again employed with successive quantities of milk, a limit is reached when the one pound of gelatine has been incorporated with ten gallons. At this stage the mixture will contain no more than one part of gelatine

to ten of the nutritive matters of milk—a proportion of added preservative material which contrasts very favorably with the 25 to 28 per cent. of sugar found in ordinary condensed milk. If the one pound of gelatine required could be at once dissolved in the whole eight or ten gallons of milk, the process would be simplified and cheapened; but gelatinization could not then be secured, for it is the gradual drying up of the slabs of jelly, with which the animal and vegetable food materials have been uniformly incorporated, that envelops every particle of changeable substance with an adequate protective coating of gelatine.

Notes on Afghanistan.—Afghanistan is happily described by a writer in the *Geographical Magazine* as a star of valleys radiating from the stupendous peaks of the Koh-i-Baba, and bounded all round by very rugged and difficult mountains. These valleys are traversed by streams which flow in various directions, the most important of them being the Cabool and its tributary the Kunar, the Argandab, the Helmund, the Harirud, and the Murghab. The appalling grandeur of some of the defiles north of the Hindoo-Koosh—a name applied to the whole line of Alpine water-shed stretching southwest from the southern end of Pamir—is not surpassed anywhere, while many of the sheltered glens on the southern slopes of that range are the delight of travelers. The general elevation of the country, which is considerable, diminishes toward the frontiers, and as its face becomes lower the rivers are absorbed by irrigation or lost by evaporation, and a belt of very barren, desert-like land is thus formed, bounding Afghanistan on all sides except the northeast corner. The spurs of the Hindoo-Koosh run out on both sides into the basins of the Oxus and the Cabool. Its peaks in all probability rise throughout to the region of perpetual snow, and the loftiest attain 20,000 feet in height, or over. This mighty range is pierced by upward of twenty passes, all leading from the basin of the Oxus to that of the Cabool. The climate is very diversified, but this is due to difference of elevation rather than of latitude. At Ghazin (7,730 feet) the winters are very severe, and here, as well as in the Hazarajat, the people stay in their houses during the cold season. The summer heat is everywhere very great, except in the most elevated parts of the Hindoo-Koosh and other lofty mountains. A deadly hot wind blows over the southwestern portion of the country, which is a sandy and almost uninhabited desert. For nine months the sun shines with the greatest possible splendor in Afghanistan, and the nights are even more beautiful than the days. The geology of the country is but little known. Antimony, iron, and lead, are found in the Ghorband Valley, and quarries of white marble in the hills near Maidan. Copper is found in various localities, but the deposits are unworked. Lead is obtained from the Hazara country; sulphur from Pir-Kisri, on the eastern confines of Seistan; and zinc and nitre from the Zhob Valley and Herat respectively. The main wealth of Afghanistan consists in the domestic animals—the horse, camel, cow, etc. The population is estimated at a little below 5,000,000. Wheat is the staple food; rice is largely grown; other agricultural products are turnips, ginger, turmeric, sugar-cane, castor-oil plant, madder, asafœtida, tobacco, and fruits.

Japanese Fermented Liquors.—Some time ago Prof. De Bary, of Strasburg, discovered that alcoholic fermentation can be effected by the growth of a species of *Mucor*. Singularly enough, as we learn from a communication in *Nature*, by Prof. R. W. Atkinson, of the University of Tokio, this agency for bringing about alcoholic fermentation has long been known in Japan breweries, where it is employed in preparing from rice the alcoholic liquid called *saké*. In the breweries at Hachiôji the main room is usually one hundred and twenty by fifty feet, and twenty-five or thirty feet high; along the middle of it is a platform about twelve feet from the ground; on this are ranged wooden tubs, which serve for the preparation of the ferment, an operation repeated several times during the brewing-season. At the close of the previous season a quanty of green mould is produced on rice by exposing steamed rice mixed with ashes, and over which the spores of this fungus have been scattered in a well-closed chamber—the "fungus-chamber"—a small room

about seven feet high, six feet broad, and eight feet long, well lined and covered with straw and matting, so that its high temperature may be kept up for a considerable time. In this chamber the rice and spores are left about ten days, and then they are found to be covered with a green fungus full of spores. This product is called in Japanese *tané*, or seed. When it is required to commence operations a similar method is adopted—that is, a quantity of steamed rice is placed on wooden trays in the "fungus-chamber," but not mixed with wood-ashes, and then *tané* is scattered over it, and the chamber kept closed for from two to four days. The rice-grains are then found to be covered with large quantities of fine, hair-like threads—the *mycelium* of the fungus. In this state it is called *koji*. To prepare his yeast, the brewer mixes steamed rice with thirty per cent. of its weight of *koji* and sufficient water to make a thick mud, in shallow tubs, which are kept on the central platform. It is frequently stirred with wooden tools for about ten days, and thus the grains of rice are broken down, the whole assuming a much thinner consistence, and the liquor becoming decidedly sweet. This is a change for which the author cannot yet fully account. After the end of the ten days this product is mixed with freshly-steamed rice, water, and *koji*, and placed in larger wooden vessels, in which the mixture is heated by means of closed wooden tubs containing hot water; and the temperature is maintained for from eight to thirteen days at about 95° Fahr. Meanwhile there is continuous development of gas, and a scum gradually forms on the surface till it is about an inch thick, and under the microscope presents the usual appearance of brewers' ferment—*saccharomyces*. The product of this operation is called *moto*—source, or origin—the yeast. The actual fermentation has three stages, called "beginning," "middle," and "end," the proportions of steamed rice varying slightly in each, but giving a final result of one hundred parts of steamed rice to thirty of ferment. This mixture, with the proper quantity of water, is placed in large tuns, and allowed to remain fifteen days, during which there is active fermentation, and the liquid becomes strongly alcoholic, at the end of which time it is drawn off from the grains of rice which have subsided, and put in other tuns, where it stands till the remainder of the rice is separated. The liquor is now heated to 140° Fahr., after which it is kept in store vats, carefully sealed up. This *saké* contains about fifteen per cent. alcohol.

A French Agricultural School.—It is a true remark that in France sundry matters of practical administration are better understood than elsewhere, and it may be that an account of a French agricultural school will suggest a few useful ideas to those who conduct similar institutions in this country. At Grignon, near Versailles, is an institution of this kind, concerning which the *Revue Scientifique* gives the following notes: There are three classes of students, viz., *internes*, or boarders, who constitute the majority; *externes*, who live outside of the institution, but who are required to attend all the exercises of the school; and *auditeurs libres*, who are free to select among the different courses of instruction such as they prefer. Students of the first class pay 1,200 francs per annum for board, lodging, and tuition, and those of the other two pay 200 francs. The course of study extends over a period of two and a half years, and pupils are admitted in October after passing an examination. In March, at the close of the first semester, they are examined on the subjects they have studied during this first term, and those who do not pass this ordeal successfully are dismissed. Similar eliminatory examinations take place at the end of each semester. The final examination is in March, thirty months after admission, the most meritorious students receiving diplomas, and the others a certificate of study. The number of branches taught is considerable, viz.: Chemistry, both general and agricultural; rural economy; agriculture; rural engineering; botany; technology; silviculture; zoötechny; meteorology, and geology. In addition, instruction is given in book-keeping and in hygiene, and there are lectures on special subjects. The instruction given in each branch of study is fortified by practical applications under the direction of the professors and

their assistants, and the students are familiarized with chemical manipulation, the determination of the different kinds of minerals and plants, draughting, land-surveying, the management of animals, agricultural machines, etc. The farm attached to the school comprises 300 hectares (about 750 acres).

Noxious Vapors and Health.—In the report of an English commission on noxious vapors given off in the course of various manufactures, a principle is laid down which, if accepted by courts, would afford a speedy remedy for many of the ills of modern life. What the report says with special reference to alkali and copper works may be applied to such nuisances as fat-rendering and petroleum-refining establishments; also to such destroyers of quiet as elevated railroads. "To be free from bodily discomfort," says the report, quoting the words of Mr. Simon, "is a condition of health. If a man gets up with a headache, *pro tanto* he is not in good health; if a man gets up unable to eat his breakfast, *pro tanto* he is not in good health. When a man is living in an atmosphere which keeps him constantly below par, as many of those trade-nuisances do, all that is an injury to health." But it is more than doubtful whether the commission will be able to enforce any measures that will effectually abate these nuisances. It is admitted that, besides the direct injury to the public health, noxious factory-gases are chargeable with doing serious damage to agriculture. Cattle die from grazing on poisoned herbage, farms become parched up, yellow, and cannot be tenanted; parks, woodlands, and hedges, are slowly annihilated. But the factories give employment to the population, and working-people are content to labor even in an unwholesome atmosphere for their daily bread. To require the entire suppression of nuisances involves outlay of money, and, in the present depressed state of manufacturing industry in Britain, proprietors are unwilling to incur expense. They would close their establishments, so throwing people out of employment, rather than burden themselves with the cost of carrying out the provisions of such a law as the sanitarians demand. Said the President of the Salt Chamber of Commerce: "We are taking no steps whatever to consume our own black smoke. The local authority must fine me as long as they can; if they fine me to too great an extent I shall have to shut up. This will be the case with all of us, and the trade will be driven from the district."

A Defense of the Sparrows.—Dr. Elliott Coues's "railing accusations" against the English sparrow have called forth many a hot-tempered reply from the friends of that bird, some of whom are so unpatriotic as to prefer the foreign intruder to the feathered songsters of their native land. Among these partisans of the English sparrow must be numbered Mr. Robert B. Roosevelt, who, in a late number of *Forest and Stream*, scruples not to answer "railing with railing." Dr. Coues, it will be remembered, makes five distinct categories of the sparrow's friends; Mr. Roosevelt does not care to differentiate the bird's enemies, but lumps them in one class, the "sparrow-hawks." The sparrows are worthless idlers, say these sparrow-hawks; but what, asks Mr. Roosevelt, was the condition of our city parks and tree-shaded streets before the advent of the sparrows? Were they not practically impassable from the numbers of disgusting measuring-worms which hung in festoons from the limbs of the trees? The parks were abandoned absolutely to the worms, which by June had stripped every leaf, often killing the trees, and making them as bare and denuded as in mid-winter. The sparrows came, and everything was changed. "But," say the sparrow-hawks, "our native birds might have done the same service." "Might have done!" exclaims Mr. Roosevelt, contemptuously; "they never did." On the other hand, the sparrows "did not pave the parks with good intentions, but set about their appointed work and did it. They did not idle on bush or limb to squeak a feeble attempt at harmony" (such is the fling the author makes at our native feathered songsters); "they did not slip off to steal fruit; they did not satisfy their minds and feel that they had performed the whole duty of birds by setting up their feathers and saying, 'How pretty I am!' They were expected to kill worms, and they killed them. Early and late, without folly or idleness or

wicked indulgences, they performed their duty till the measuring-worms ceased to be, and the place that knew them knows them no more. Go on, good sparrow!" But we have not the space to give the eloquent apostrophe in which the author encourages the sparrow to go on with his good work.

Death of Mr. Thomas Belt.—With deep regret we have to announce the death of Thomas Belt, geologist and naturalist. He died, September 22d, at Denver, Colorado, of rheumatic fever. The following biographical notice is from the London *Athenæum:* "The son of the late Mr. George Belt, nurseryman and seedsman of Newcastle-upon-Tyne, Thomas Belt was a practical botanist almost from his infancy, and his scientific tastes were further developed in the two schools which he attended—the earliest presided over by Dr. J. C. Bruce, of antiquarian fame, and the second by the late John Storey, a man second to none of his day as a north-country botanist. In the latter establishment young Belt had as schoolfellows two boys who have since stamped their names in the annals of science—Prof. G. S. Brady and H. B. Brady, F. R. S. In 1851 Thomas Belt joined in the first great gold rush to Australia, and since that time his life has been that of a hard-working, successful mining engineer. He visited all parts of the world in the course of his profession, but whether as a digger in Victoria, as a manager of mines in Central America, or as a prospector in the wilder parts of Russia, the engineer was always a naturalist at heart. He was an excellent observer, and a certain speculative tendency led him to group his observations so as to bring out their full theoretical bearings. He was minutely accurate in his description of facts, and bold in his generalizations. He covered so much ground that some of his theories may not bear the test of further research, but some will stand, and all bear witness to the singular grasp of his mind. The chief results of his work are to be found in his papers read before the Geological Society (of which he became a Fellow in 1866), and in a most interesting book entitled 'The Naturalist in Nicaragua,' and published in 1874. In biology Mr. Belt was an advanced evolutionist, and in geology an ultra-glacialist. In both branches of science his papers were suggestive in the highest degree. What he did was so good that much was expected of him, and his sudden loss is an irreparable one to the rapidly-thinning group of eminent Tyneside naturalists to which, by right of birth, he belonged."

NOTES.

The American Public Health Association will hold its sixth annual meeting at Richmond, Virginia, beginning on the 19th and ending on the 22d of November. The first days of the session will be devoted to the report and evidence submitted by the Yellow Fever Commission recently named by the Surgeon-General of the Marine Hospital Service.

The project of a railroad across Newfoundland is again being agitated. Such a railroad would have the effect of shortening by one thousand miles the ocean-voyage from this continent to Europe. It is stated in the *Polytechnic Review* that the Government of Newfoundland has agreed to vote an annual subsidy, and to make a grant of lands in aid of the enterprise. Among the incidental benefits to be derived from such a line of railway may be named the opening up of vast deposits of copper, iron, coal, nickel, lead, and other minerals. Furthermore, it would cut through the great pine and spruce forests of the interior of Newfoundland.

Sir George Nares, who commanded the expedition of the Alert and Discovery to the polar regions, is about to make another scientific voyage to the South Pacific. He will first make soundings in the track of navigation between New Zealand and Feejee, and will then ascertain the positions of the different reefs and islets off the northwestern coast of Australia.

Dr. J. S. Meyer, of Virginia City, Nevada, claims that he has discovered the "lost art," known to the ancient Egyptians, of tempering copper so as to produce an edge which will cut like steel.

The Government in India is introducing agricultural schools. The native methods are wretchedly poor, and little wonder is it that the famines are occasionally dreadful. "The curse of Indian agriculture" is said to be the inveterate custom in many places of using the cattle-manure for fuel. To stop this a law is recommended for the compulsory planting of fuel trees, which also would have a good climatic effect.

A German resident on the island of Java has succeeded in domesticating the native honey-bee (*Apis dorsata*). The hope is indulged that this Javanese bee may be acclimated in Europe, and, if so, in America. The only value hitherto set upon the insect by the natives has been for its larvæ, which they used for food.

The distinguished geologist and engineer, Sir Richard John Griffith, Bart., died in Dublin, September 22d, aged ninety-four years. In 1854 was completed his "Geological Map of Ireland," for which he received the Wollaston Medal of the London Geological Society. From an early age till 1864 he was connected with the Irish Board of Public Works, and was chairman of the board for the last twelve years of that period.

The editor of the *American Builder*, in looking over the statistics of education in the United States, observes some facts which strike him as curious, for instance, that while there are 579 colleges, universities, law, medical, and theological schools, there are only 83 schools for the higher mechanical and scientific education, including all schools of design, mining, and engineering. Again, the theological schools are twice as numerous as the engineering, scientific, and mechanical schools. "No wonder," he remarks, "that many trained preachers in this country go hungry to bed, while thousands of enterprising mechanics and artisans are floundering in a sea of ignorance in search of higher scientific attainments."

Prof. Fischer, who was lately found dead in the laboratory of the Prague Gymnasium, was the victim of a theory. Having mixed sal-ammoniac with cyanide of potassium, he bade his attendant to note how "science has advanced so far as even to be able to render harmless so dangerous an agent as cyanide of potassium." With that he tasted the mixture, and was quickly seized with violent pains, and expired before a physician could arrive.

A striking illustration of the value of the electric light at sea was given during the homeward voyage of the telegraph-steamer Faraday from New York to London last August. About 10.30 p. m., July 18th, in the vicinity of George's Bank, in a dense fog, with a fresh westerly wind, suddenly was heard the sound of a bell ringing furiously but a short distance ahead. The steamer's engines were immediately stopped, and the captain, supposing it to be a fisherman at anchor or almost stationary, ordered the wheel to be ported; at the same moment the electric light of the Faraday pierced the fog, and plainly showed a ship crossing her bows. Not a moment was to be lost, and only by the coolness and presence of mind of the captain was a fearful calamity averted. The two vessels were within a few feet of each other; the lookout men said they could have stepped on the stranger's stern. She was full of passengers, and the cries of women and children were heartrending. "Had I not been able," writes the captain, "to see her so plainly, and the way she was going, we must have gone over her, or she might have struck us on the port bow; in either case the loss of life must have been great, and even now it seems terrible to contemplate."

Color-blindness is, according to M. Favre, consulting physician of one of the great railways of France, a frequent result of the abuse of alcohol and tobacco. He would interdict to every railway-man holding a responsible position the use of tobacco or alcohol in any form, because they tend to impair not only the power of discriminating colors, but also that of estimating distances and of perceiving objects.

The piano war having ended, at least in the newspapers, the war of the mineral waters appears to have succeeded to its place. There are two kinds of mineral waters, the natural and the artificial. The natural waters alone possess all the medicinal virtues of the sources after which they are named—as Apollinaris, Seltzers, Vichy, etc.—at least so we are assured by the "naturalist" faction. The other side, the "artificialists," claim that their product is best and purest; besides, they boldly assert that their adversaries are no better "naturalists" than themselves; that, in fact, the so-called "natural" mineral waters are freely doctored, and hence artificial. One of the "artificialists" is out in a circular, in which he quotes from the very chemists of the opposite side, to show that the Apollinaris water imported into this country differs very much from the water as it comes from the Apollinaris spring. The natural water contains of chloride of sodium 4.66 parts in 10,000, but the bottled article contains 14.088 parts. Further, the iron of the original water is removed, and the water is charged artificially with carbonic-acid gas. Hence, it is claimed, this product is strictly "artificial."

The governor of the Chinese province of Chihli has employed Mr. Arnold Hague, of San Francisco, an expert mining engineer, to examine and report on the mineral resources of Northern China.

On the occasion of the inauguration of the monument to Giordano Bruno, the Italian Government will publish the complete works of that great and original philosopher.

GUSTAV WALLIS.

THE

POPULAR SCIENCE MONTHLY.

JANUARY, 1879.

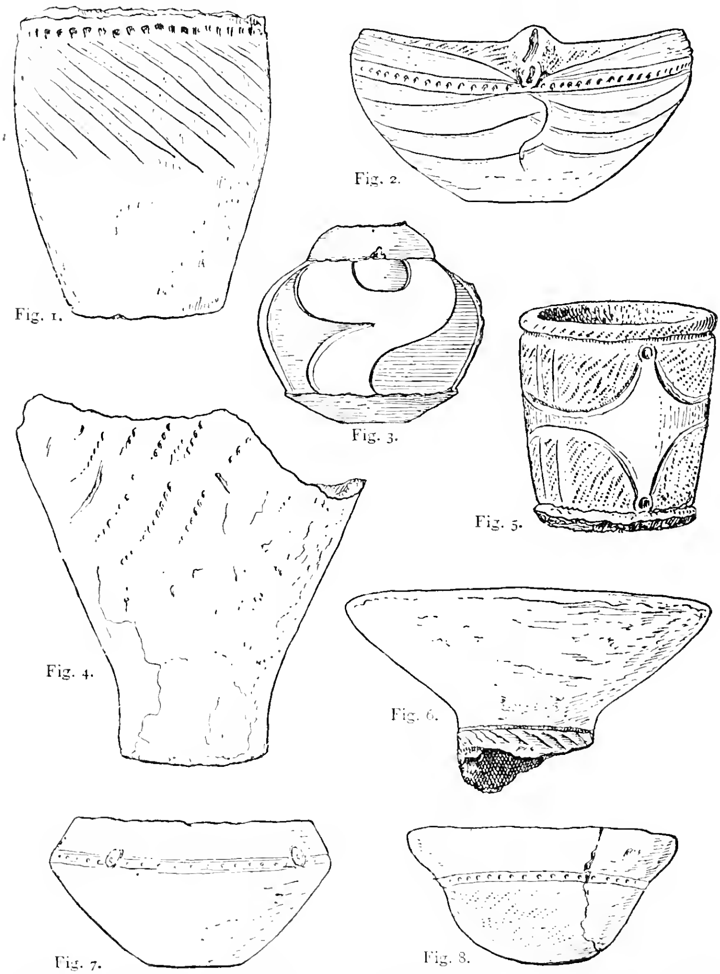
TRACES OF AN EARLY RACE IN JAPAN.

By EDWARD S. MORSE.

THERE is no race of people in whose origin we are more interested than in that of the Japanese. Their history going so completely back for nearly two thousand years, their civilization, which in so many respects parallels our own—the various epochs in our history being typified again and again by similar ages in Japan—all excite our deepest interest. The difficulty of tracing out ethnical affinities either through their personal peculiarities or their language presents a problem yet unsolved. That they are a composite race we cannot doubt. All their traditions point to their coming from the south, and equally sure are we that when they landed they found a hairy race of men to contest their occupation. Later history shows that a number of Chinese invasions took place, and these unwelcome visits were returned by the Japanese. Corea was invaded by the Japanese long ago. With these facts in mind, we are no longer surprised at the great variety of faces to be met with in Japan—faces purely Chinese; others with the coarser features of the northern tribes; and again the delicate and pleasant features of what is supposed to represent the typical Japanese.

The conjectures and opinions that have been advanced regarding the origin of the Japanese would form a curious and bulky collection. It is worth noting that both pagan and Christian writers have held almost equally preposterous notions regarding the origin of the Japanese. The people themselves have a tradition that they owe their origin to the sun. Kämpfer holds the absurd idea that "they are descended from the first inhabitants of Babylon." From these vagaries we pass in turn to other ideas based on some foundation of fact. In a paper read before the Asiatic Society of Japan by Mr. Aston, an affinity is

shown to exist between certain words in the Japanese and Aryan; while Mr. Brooks, in the proceedings of the California Academy of Sciences, takes ground for believing that the Japanese and Chinese may have been derived from the west coast of South America. Mr. Isawa, an intelligent Japanese student, at the last meeting of the American Association for the Advancement of Science, called attention to the simi-



Figs. 1 to 9 show some of the various forms of vessels. Fig. 1, diameter, 130 mm. Fig. 2, diameter, 280 mm. Fig. 3, diameter, 130 mm. Fig. 4, height, 220 mm. Fig. 5, diameter, 105 mm. Fig. 6, diameter, 160 mm. Fig. 7, diameter, 150 mm. Fig. 8, diameter, 150 mm.

larity existing between many Japanese words and Hindostanee. With these and many other conflicting views, authorities seem to agree upon one thing, and that is, that the present inhabitants of Japan are not autochthonous, neither the Japanese nor the Ainos in Yesso.

So far as the ancient records of Japan are to be relied upon (and they certainly go back before the Christian era with considerable accuracy), Jimmu Tenno in the first century of our era came from a province in Kinshin for the conquest of Niphon or Japan. The invaders met with so courageous a resistance that they were obliged to go back to their own shores. The people who repulsed Jimmu Tenno and his followers are believed by the Japanese to have been the hairy men of Yesso, the ancestors of the present inhabitants of the northern islands.

The study of the language, traditions, and folk-lore of the Ainos, furnishes good reasons for believing that the ancestors of the Ainos came from Kamtchatka, drifting down through the Kuriles, and gradually becoming proprietors of the soil before the Japanese came from the south to displace them.

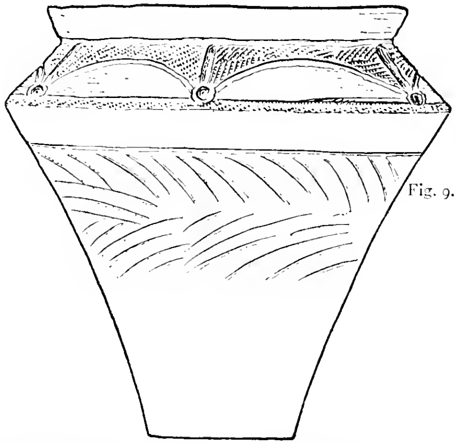


Fig. 9.

Fig. 9—the rims of this vessel are quite common in the heaps, but only one, the fragments of which could be matched, was found. Its height was about 300 mm.

With every reason for believing that the Japanese came from the south, displacing the Ainos, who came from the north, the question next arises as to the original occupants of the island. Did the northern people encounter resistance from a primitive race of savages, or were they greeted only by the chattering of relatives still more remote, whose descendants yet clamber about the forest-trees to-day? The records are silent on these points. A discovery that I made in the vicinity of Tokio last year leads me to believe that possibly the traces of a race of men previous to the Aino occupation have been found. I say possibly, because a study of the Aino people, their manners, and traces of their early remains, is necessary before a definite opinion can be formed.

On my first visit to Tokio I discovered from the car-window a genuine "Kjoekkenmoedding," or shell-heap, as we call them. The deposit is in Omori, about six miles from Tokio; and one may well wonder why it had not been recognized before. It had probably often

been seen, but, like many similar deposits in Europe and America, had been looked upon as natural beds of sea-shells deposited in past times, and after their formation elevated by upheaval. It was not until Steenstrup, of Copenhagen, first took up the critical study of similar deposits along the shores of the Baltic, and showed that the deposits were really the work of man, and of ancient man, that attention was attracted to these beds in other parts of the world.

Thanks to several years' study of these deposits along the coast of New England, in company with Prof. Jeffries Wyman, I was enabled to recognize the character of the Omori deposit at once. The railway passes directly through it, and most of it has been removed for ballasting the road. The bed evidently covered the field beyond the track for a considerable distance, judging from the quantity of shells and fragments of pottery which were strewed in the adjacent rice-field. The deposit varied from a few inches to two feet and a half in thickness, and the layer of earth above varied from two feet to nearly five feet in thickness. This great depth of soil above the shells might have been brought in by man, as the Japanese are famous for the manner in which they level the ground and fill in depressions. The thickness of soil above a deposit is always an untrustworthy guide in estimating the age of such a deposit: as, for example, the deposits about Salem, Massachusetts, containing precisely the same kinds of pottery and bone-implements, and presumably of the same age, will have in one place a thickness of two feet of soil above, and in the sterile pastures a thin layer of a few inches. The Omori deposit is made up of shells which still live in the bay of Yeddo, though I have not yet been able to study the living forms sufficiently to ascertain whether any changes have taken place in the fauna since the heaps were made. A number of genera are found, representing, among others, *Eburna*, *Turbo*, *Ceritheum Arca*, *Pecten cardium*, two species of *Ostrea*, and, curiously enough, large valves of the common clam, *Mya arenaria*, hardly to be distinguished from the same species so common along the New England coast. The position of the Omori heap is striking. The shell-heaps of New England, Florida, and nearly all places where they have been observed, are always in immediate proximity to the shore or river. In some places, as at Goose Island, Maine, the ocean encroaches upon the deposits and is gradually removing them. Rev. James Fowler, in commenting upon the absence of shell-heaps along the New Brunswick coast, offers this as one of the evidences that the sea is encroaching upon the land, and calls attention to the fact that buildings, which stood at some distance from the shore fifty years ago, have since been washed away.[1] Along the shores of the Baltic, the shell-heaps, on the contrary, are a mile or more from the shore, and this fact, with evidences of a geological character, shows a practical encroachment of the land upon the sea by upheaval since the deposits were made.

The Omori deposits, like those of the Baltic, are some distance from

[1] "Smithsonian Annual Report" for 1870, p. 389.

the sea-shore—nearly, if not quite, half a mile. And that an upheaval has taken place since the deposits were made, there can be no doubt. Geological evidences are not wanting to support this view; these various deposits, remote from each other, such as the Denmark, New England, and Florida deposits, have each their peculiarities. In the Danish heaps there seems to be a scarcity of pottery, but an abundance of flint-chips and rude stone implements, as well as implements worked out of horn and bone. The New England shell-heaps are not rich in pottery fragments, the stone implements are rude and scarce, but the implements of horn and bone are comparatively not uncommon, those worked out of bone being more common. In the Florida deposits fragments of pottery are more abundant; and while rude stone and bone implements are found, the larger shells seem to have furnished them with material for many of their implements. Prof. Wyman has figured many of them in his memoir on the fresh-water shell-heaps of Florida, and Dr. Stimpson has figured an awl in the *American Naturalist*, which was made out of the spirally grooved columella of *Fasciolaria*. While the pottery of Denmark and New England is ornamented by incised lines and "cord-marks," the Florida pottery bears the marks of stamps by which they impressed a rude ornamentation upon their vessels. The Omori shell-heap has also its peculiarities: 1. The extreme abundance of pottery, both in fragments and nearly perfect vessels. From the great quantity found there, one is led to believe that in past times it was a famous place for its manufacture. Yet in the excavations no masses or unfinished vessels were found to justify this assumption. 2. The great variety in the form of the vessels and remarkable diversity in their ornamentation. From these characters alone one might infer it to be of more recent origin. Its rudeness, however, and the absence of anything like lathe-work or glazing, show it to be ancient.[1] A greater portion of the pottery has the twisted cord-mark so common in most of the early pottery. Much of it has incised lines, and small fragments show a peculiar carving, made after the clay was dry, but before baking.

The ornamentation in these fragments is almost precisely similar to the Aino style of ornamenting. In other pottery also the peculiar way in which spaces between curved lines are "filled in," either by "cord-marks" or punctures, again recalls the Aino. And had nothing else been found in the deposit, the remains might have unhesitatingly been referred to the Yessoines. Such comparisons are unsafe, as Mr. Frank H. Cushing, of the Smithsonian Institution, finds similar pottery

[1] A writer in one of the Yokohama papers calls attention to the fact that a fragment of glazed pottery was found, when the excavations were first made, against the exposed bank of the railway. He might have added that an English button and the soldered disk of a tin preserving-can were also found! Such a one, finding a living toad in a granitic crevice, would be likely to infer, either that the toad was as old as the granite, or that the granite was as recent as the toad.

in Northern New York and Canada, and I may add that in New England such pottery has been found. In many cases the borders of vessels are ornamented with undulating ribs, showing the marks of "finger-squeezing." A marked peculiarity of the pottery consists in the eleva-

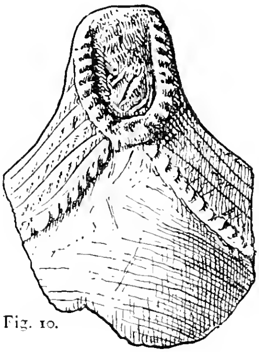


Fig. 10.

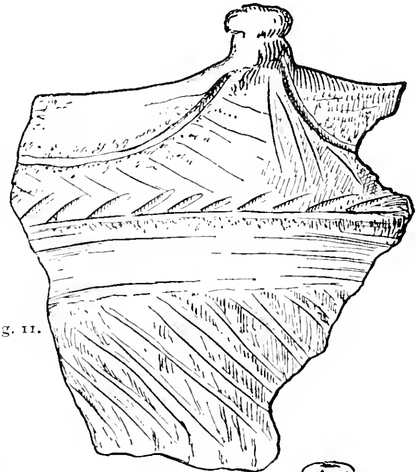


Fig. 11.

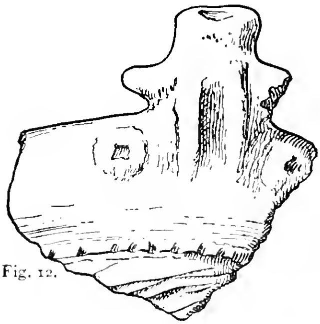


Fig. 12.

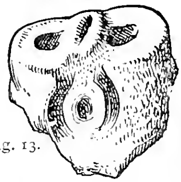


Fig. 13.

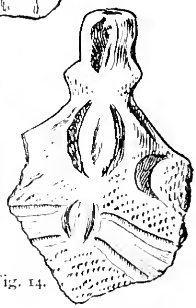


Fig. 14.

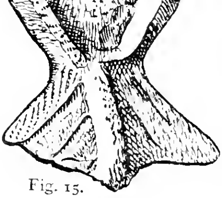


Fig. 15.

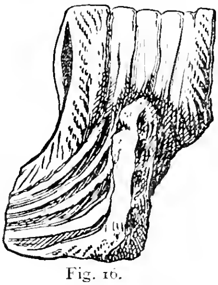


Fig. 16.

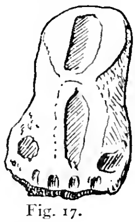


Fig. 17.

Figs. 10 to 17 show a few of the knobs or handles which are peculiar to the Omori deposit. Not a single vessel was found with legs, as with the Central American pottery, but most of the vessels have raised knobs on the margin. Fig. 16 is looped, so that a wooden handle might be adjusted. Fig. 11 is 190 mm. in its longest diameter; the size of the other knobs may be estimated from this.

tion of the rim or border into ornamented knobs or handles, some of which are represented in Figs. 10 to 17 inclusive. Some painted pottery was also found, the coloring matter of which, on analysis by Prof. Jewett, of the Imperial University of Tokio, proves to be cinnabar. The

occurrence throughout the empire of stone celts, finished arrow-heads, and spear-points and pestles, is common. These might or might not have belonged to the Ainos, though, as similar forms occur in Yesso, the probability is that many of them at least are of early Aino manufacture. It is significant, however, to observe that the few stone implements found in the Omori beds are of the rudest manufacture; and, furthermore, that no shell-heap that I know of has revealed a less number, the two shown in Figs. 28 and 29 being made of a soft volcanic rock. Curiously enough, most of the other implements were made out of deer's-horns, only one being of bone (Fig. 21, evidently the end of a deer's metatarsal). An exquisitely finished arrow-point (Fig. 25) was fabricated out of a boar's tusk.

The bones of birds were not common. I searched in vain for traces of the great auk, the remains of which are so widely met with in Denmark and New England. Though ponderous shells of various species occur in the heap, no evidence was found that these were worked in any way.

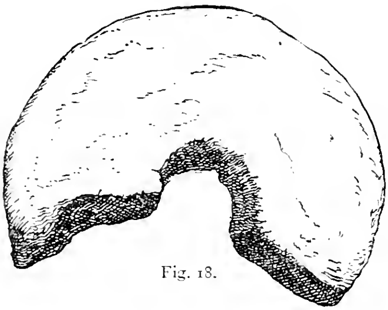


Fig. 18.

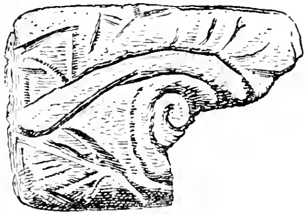


Fig. 19.

Fig. 18 is a piece of pottery that may be a spindle-whorl—diameter, 70 mm.
Fig. 19 is a small clay brick, 55 mm. in length. This is ornamented on both sides. It is difficult to conjecture its use. I have four more in the collection at the university, much larger and ornamented in a different manner. These are possibly amulets, or perhaps signs of office or authority. I think they are unique.

A fragment of a spindle-whorl is shown in Fig. 18. A peculiar tablet, or brick of clay, curiously ornamented, is shown in Fig. 19. Nothing of the kind, so far as I know, has been found in the shell-heaps of other parts of the world. It is difficult even to conjecture its use.

The most important discoveries connected with the Omori deposits are the unquestionable evidences of cannibalism. Large fragments of the human femur, humerus, radius, ulna, lower jaw, and parietal bone, were found widely scattered in the heap. These were broken in precisely the same manner as the deer-bones—either to get them into the cooking-vessel, or for the purpose of extracting the marrow—in all respects corresponding to the facts cited by Wyman in proof of the evidences of cannibalism found in the Florida and New England shell-heaps.

The question as to the antiquity of the Omori deposits naturally arises, and the evidences all point to a considerable antiquity, suggested by the entire absence of worked metals, as well as of finished or polished stone implements, the few implements found being of the rudest character.

The change which has taken place in the coast-line by upheaval, since the deposits were made, has not the importance which would be ascribed to it in a more stable country.

The next question arises as to whether the deposits are Aino or pre-Aino. The race who left these remains were pot-makers *par excellence.* It is generally admitted by ethnologists that the art of pottery once gained is never lost. It is a fact, however, that neither the Esquimaux, Aleutians, Kamtchadales, nor the Ainos, are essentially earthen-pot makers, their vessels being usually wrought out of stone or wood, and their ancient stone vessels are often met with in various parts of Japan.

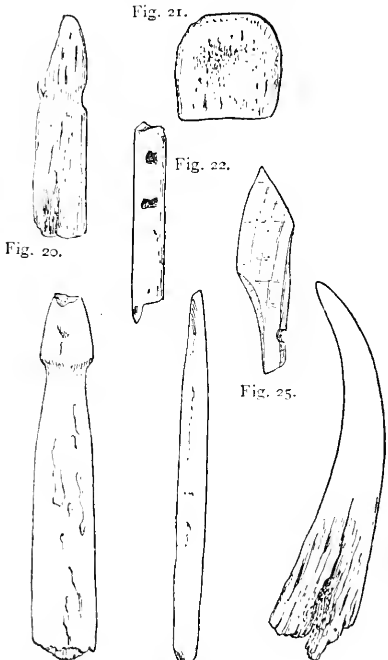


Fig. 20. Fig. 21. Fig. 22. Fig. 23. Fig. 24. Fig. 25. Fig. 26.

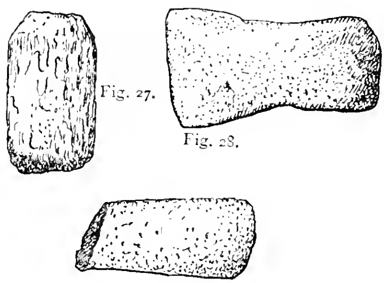


Fig. 27. Fig. 28. Fig. 29.

Figs. 20 to 26 represent a number of implements made out of horn, with the exception of Fig. 25, which is worked out of a boar's tusk. Figs. 23, 24, and 26, are respectively 60, 62, and 125 mm. in length. Fig. 21 is worked out of the end of a deer's metatarsal. Fig. 22 is a bird's bone, probably a humerus, with two holes worked in it.

Fig. 27 is a portion of deer's antler cut at both ends and broken.

Figs. 28 and 29 are two stone implements, worked out of soft lava-rock. They are respectively 50 and 70 mm. in length.

If the unquestionable resemblance between the ornamentation of some of the fragments and similar styles of ornamentation among the present Ainos be looked upon as indicating a community of origin, what shall be said of the following figures of knobs found in a shell-heap on the Upper Amazon by the lamented Prof. Hartt? The knobs themselves are so unlike anything figured heretofore, and yet so precisely do they resemble similar knobs which are most common in the Omori deposits, that were they mixed with the collection it would be

impossible to separate them by a single character!—even to the depression on top and in front, as shown in Fig. 12.

A curious stone ornament, having the general shape of a comma, with the big end perforated, is known as the *magatama*. These peculiar-shaped objects are looked upon as ornaments belonging to the primitive inhabitants of Japan. Mr. Borlase [1] says the traditions about them have been handed down from mythological times.

Siebold says: "To this day they are in use among the Ainos of Yesso and in the Kuriles, as precious ornaments, under the name of *sitogi*. The inhabitants, too, of Liukiu wear a stone resembling the *magatama*; so that this little jewel helps us to a noteworthy historic fact, namely, to the connection which in remote times existed between the inhabitants of the whole chain of islands from Taiwan to Kamtchatka."

An exhaustive examination of the Omori deposits did not reveal anything like a *magatama*.

Were the Ainos cannibals?

Repeated inquiries among eminent Japanese scholars and archæologists, like Mr. Kanda, Mr. Ninagawa, and others, as to this question, are always answered in the same way. Not only were they not cannibals, but they are reported as being so mild and gentle that murder was never known to have occurred. So monstrous a habit would certainly have been known and recorded, particularly in the painstaking annals of early historians.

In conclusion, then, the Omori shell-heap presents all the leading characteristics of the typical Kjoekkenmoedding. And the evidences

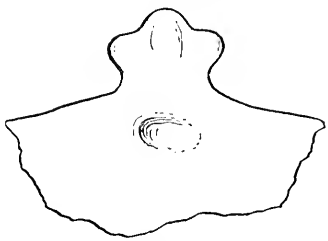


Fig. 30.

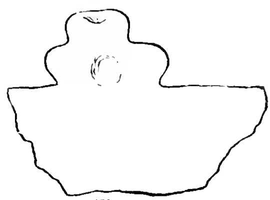


Fig. 31.

which Prof. Wyman cites as evidence of cannibalism, in the shell-heaps of Florida and Massachusetts, are likewise present in the Omori deposit. The recent occupation of America by the white race renders it difficult to determine how recent the shell-heaps along the coast may be, since the savages when first encountered were living in much the same condition as their ancestors had lived, just as to-day there still exist in some parts of the world veritable Stone-age savages. In Japan, however, where historians have chronicled with remarkable fidelity the minute details of their history, we get, as it were, some standard for

[1] "Niphon and its Antiquities."

time in estimating the age of the Omori deposits. It can be stated with absolute certainty that they are pre-Japanese; and there are as good reasons for believing them pre-Aino as early Aino.

I have to return my sincere thanks to the university authorities for the zeal they have displayed in assisting me in the examination of the deposits, and to the personal help afforded me in the excavations by Profs. Yatabe, Toyama, and Dr. David Murray, Messrs. Matsumura, Sasaki, Matsura, Fukuyo, and others. I made a special request that the deposits should be completely examined during my absence, and this examination was most faithfully done. A much larger collection was made with many new and curious forms of pots. I hope at some future time to illustrate them.

VIRCHOW AND EVOLUTION.[1]

By Professor JOHN TYNDALL.

THIS world of ours has, on the whole, been an inclement region for the growth of natural truth; but it may be that the plant is all the hardier for the bendings and buffetings it has undergone. The torturing of a shrub, within certain limits, strengthens it. Through the struggles and passions of the brute, man reaches his estate; through savagery and barbarism his civilization; and through illusion and persecution his knowledge of Nature, including that of his own frame. The bias toward natural truth must have been strong to have withstood and overcome the opposing forces. Feeling appeared in the world before knowledge; and thoughts, conceptions, and creeds, founded on emotion, had, before the dawn of science, taken root in man. Such thoughts, conceptions, and creeds, must have met a deep and general want; otherwise their growth could not have been so luxuriant, nor their abiding power so strong. This general need—this hunger for the ideal and wonderful—led eventually to the differentiation of a caste, whose vocation it was to cultivate the mystery of life and its surroundings, and to give shape, name, and habitation to the emotions which that mystery aroused. Even the savage lived, not by bread alone, but in a mental world peopled with forms answering to his capacities and needs. As time advanced—in other words, as the savage opened out into civilized man—these forms were purified and ennobled, until they finally emerged in the mythology and art of Greece:

> "Where still the magic robe of Poesy
> Wound itself lovingly around the Truth."[2]

[1] Introductory chapter to a forthcoming volume of "Fragments of Science."

[2] "Da der Dichtung zauberische Hülle
Sich noch lieblich um die Wahrheit wand."—SCHILLER.

As poets the priesthood would have been justified; their deities, celestial and otherwise, with all their retinue and appliances, being more or less legitimate symbols and personifications of the aspects of Nature and the phases of the human soul. The priests, however, or those among them who were mechanics and not poets, claimed objective validity for their conceptions, and tried to base upon external evidence that which sprang from the innermost need and nature of man. It is against this objective rendering of the emotions—this thrusting into the region of fact and positive knowledge, of conceptions essentially ideal and poetic—that science, consciously or unconsciously, wages war. Religious feeling is as much a verity as any other part of human consciousness; and against it, on its subjective side, the waves of science beat in vain. But when, manipulated by the constructive imagination, mixed with imperfect or inaccurate historic data, and moulded by misapplied logic, this feeling traverses our knowledge of Nature, Science, as in duty bound, stands as a hostile power in its path. It is against the mythologic scenery, if I may use the term, rather than against the life and substance of religion, that Science enters her protest. Sooner or later among thinking people, that scenery will be taken for what it is worth—as an effort on the part of man to bring the mystery of life and Nature within the range of his capacities; as a temporary and essentially fluxional rendering in terms of knowledge of that which transcends all knowledge, and admits only of ideal approach.

The signs of the times point in this direction. It is, for example, the obvious aim of Mr. Matthew Arnold to protect, amid the wreck of dogma, the poetic basis of religion. And it is to be remembered that under the circumstances poetry may be the purest accessible truth. In other influential quarters a similar spirit is at work. In a remarkable article published by Prof. Knight, of St. Andrews, in the September number of the *Nineteenth Century*, amid other free utterances, the following is to be found:

> "If matter is not eternal, its first emergence into being is a miracle beside which all others dwindle into absolute insignificance. But, as has often been pointed out, the process is unthinkable; the sudden apocalypse of a material world out of blank nonentity cannot be imagined;[1] its emergence into order out of chaos when 'without form and void' of life, *is merely a poetic rendering of the doctrine of its slow evolution.*"

These are all bold words to be spoken before the moral philosophy class of a Scotch university, while those I have underlined show a remarkable freedom of dealing with the sacred text. They repeat in fuller language what I ventured to utter four years ago regarding the book

[1] Prof. Knight will have to reckon with the English Marriage Service, one of whose collects begins very naïvely thus: "O God, who by thy mighty power hast made all things of nothing."

of Genesis: "Profoundly interesting and indeed pathetic to me are those attempts of the opening mind of man to appease its hunger for a Cause. But the book of Genesis has no voice in scientific questions. *It is a poem, not a scientific treatise.* In the former aspect it is forever beautiful; in the latter it has been, and it will continue to be, purely obstructive and hurtful." My agreement with Prof. Knight extends still further. "Does the vital," he asks, "proceed by a still remoter development from the non-vital? Or was it created by a fiat of volition? Or"—and here he emphasizes his question—"*has it always existed in some form or other as an eternal constituent of the universe?* I do not see," he replies, "how we can escape from the last alternative." With the whole force of my conviction I say, "Nor do I;" though my mode of regarding the "eternal constituent" might differ from that of Prof. Knight.

When matter was defined by Descartes, he deliberately excluded the idea of force or motion from its attributes and from his definition. *Extension* only was taken into account. And, inasmuch as the impotence of matter to generate motion was assumed, its observed motions were referred to an external cause. God, resident outside of matter, gave the impulse. In this connection the argument in Young's "Night Thoughts" will occur to most readers:

> "Who Motion foreign to the smallest grain
> Shot through vast masses of enormous weight?
> Who bid brute Matter's restive lump assume
> Such various forms, and gave it wings to fly?"

Against this notion of Descartes the great deist John Toland, whose ashes lie unmarked in Putney Churchyard, strenuously contended. He affirmed motion to be an inherent attribute of matter—that no portion of matter was at rest, and that even the most quiescent solids were animated by a motion of their ultimate particles. It seems to me that the idea of vitality entertained in our day by Prof. Knight closely resembles the idea of motion entertained by his opponents in Toland's day. Motion was then virtually asserted to be a thing *sui generis*, distinct from matter, and incapable of being generated out of matter. Hence the obvious inference when matter was observed to move. It was the vehicle of an energy not its own—the repository of forces impressed on it from without—the purely passive recipient of the shock of the Divine. The form of logic continues, but the subject-matter is changed. "The evolution of Nature," says Prof. Knight, "may be a fact; a daily and hourly apocalypse. But we have no evidence of the non-vital passing into the vital. Spontaneous generation is, as yet, an imaginative guess, unverified by scientific tests. And matter is not itself alive. Vitality, whether seen in a single cell of protoplasm or in the human brain, is a thing *sui generis*, distinct from matter, and incapable of being generated out of matter." It may be, however, that, in pro-

cess of time, vitality will follow the example of motion, and, after the necessary antecedent wrangling, take its place among the attributes of that "universal mother" who has been so often misdefined.

That "matter is not itself alive" Prof. Knight seems to regard as an axiomatic truth. Let us place in contrast with this the notion entertained by the philosopher Ueberweg, one of the subtilest heads that Germany has produced:

> "What occurs in the brain would, in my opinion, not be possible, if the process which here appears in its greatest concentration did not obtain generally, only in a vastly diminished degree. Take a pair of mice and a cask of flour. By copious nourishment the animals increase and multiply, and in the same proportion sensations and feelings augment. The quantity of these latter possessed by the first pair is not simply diffused among their descendants, for in that case the last must feel more feebly than the first. The sensations and feelings must necessarily be referred back to the flour, where they exist, weak and pale it is true, and not concentrated as they are in the brain."[1]

We may not be able to taste or smell alcohol in a tub of fermented cherries, but by distillation we obtain from them concentrated Kirschwasser. Hence Ueberweg's comparison of the brain to a still, which concentrates the sensation and feeling, preëxisting, but diluted in the food.

"Definitions," says Mr. Holyoake,[2] "grow as the horizon of experience expands. They are not inventions, but descriptions of the state of a question. No man sees all through a discovery at once." Thus Descartes's notion of matter, and his explanation of motion, would be put aside as trivial by a physiologist or a crystallographer of the present day. They are not descriptions of the state of the question. And yet, it may be said in passing, a desire sometimes shows itself in distinguished quarters to bind us down to conceptions which passed muster in the infancy of knowledge, but which are wholly incompatible with our present enlightenment. Mr. Martineau, I think, errs when he seeks to hold me to views enunciated by "Democritus and the mathematicians." That definitions should change as knowledge advances is in accordance both with sound sense and scientific practice. When, for example, the undulatory theory was started, it was not imagined that the vibrations of light could be transverse to the direction of propagation. The example of sound was at hand, which was a case of longitudinal vibration. Now, the substitution of transverse for longitudinal vibrations in the case of light involved a radical change of conception as to the mechanical properties of the luminiferous medium. But, though this change went so far as to fill space with a substance possessing the properties of a solid, rather than those of a gas, the change was accepted, because the newly discovered facts imperatively demanded it. Following Mr. Martineau's example, the opponent of the

[1] Letter to Lange, "Geschichte des Materialismus," zweite Aufl., vol. ii., p. 521.

[2] *Nineteenth Century*, September, 1878.

undulatory theory might effectually twit the holder of it on his change of front. "This ether of yours," he might say, "alters its style with every change of service. Starting as a beggar, with scarcely a rag of 'property' to cover its bones, it turns up as a prince when large undertakings are wanted. You had some show of reason when, with the case of sound before you, you assumed your ether to be a gas in the last extremity of attenuation. But, now that new service is rendered necessary by new facts, you drop the beggar's rags, and accomplish an undertaking, great and princely enough in all conscience; for it implies that not only planets of enormous weight, but comets with hardly any weight at all, fly through your hypothetical solid without perceptible loss of motion." This would sound very cogent, but it would be very vain. Equally vain, in my opinion, is Mr. Martineau's contention that we are not justified in modifying, in accordance with advancing knowledge, our notions of matter.

Before parting from Prof. Knight, let me commend his courage as well as his insight. We have heard much of late of the peril to morality involved in the decay of religious belief. What Mr. Knight says under this head is worthy of all respect and attention:

> "I admit that, were it proved that the moral faculty was derived as well as developed, its present decisions would not be invalidated. The child of experience has a father whose teachings are grave, peremptory, and august; and an earth-born rule may be as stringent as any derived from a celestial source. It does not even follow that a belief in the material origin of spiritual existence, accompanied by a corresponding decay of belief in immortality, must *necessarily* lead to a relaxation of the moral fibre of the race. It is certain that it has often done so.[1] But it is equally certain that there have been individuals, and great historical communities, in which the absence of the latter belief has neither weakened moral earnestness nor prevented devotional fervor."

I have elsewhere stated that some of the best men of my acquaintance—men lofty in thought and beneficent in act—belong to a class who assiduously let the belief referred to alone. They derive from it neither stimulus nor inspiration, while—I say it with regret—were I in quest of persons who, in regard to the finer endowments of human character, are to be ranked among the unendowed, I should find some characteristic samples among the noisier defenders of the orthodox belief. These, however, are but "hand-specimens" on both sides; the wider data referred to by Prof. Knight constitute, therefore, a welcome corroboration of my experience. Again, my excellent critic, Prof. Blackie, describes Buddha as being "a great deal more than a prophet; a rare, exceptional, and altogether transcendental incarnation of moral perfection."[2] And yet, "what Buddha preached was a gospel of pure

[1] Is this really certain? Instead of standing in the relation of cause and effect, may not the "decay" and "relaxation" be merely coexistent—both, perhaps, flowing from common historic antecedents?

[2] "Natural History of Atheism," p. 136.

human ethics, divorced not only from Brahma and the Brahmanic Trinity, but even from the existence of God."[1] These civilized and gallant voices from the North contrast pleasantly with the barbarous whoops which sometimes come to us along the same meridian—shouts of the Mohawk that ought not to be heard among the groves of Academe.

Looking backward from my present standpoint over the earnest past, a boyhood fond of play and physical action, but averse to school-work, lies before me. The aversion did not arise from intellectual apathy or want of appetite for knowledge, but mainly from the fact that my earliest teachers lacked the power of imparting vitality to what they taught. Athwart all play and amusement, however, a thread of seriousness ran through my character; and many a sleepless night of my childhood has been passed, fretted by the question, "Who made God?" I was well versed in Scripture; for I loved the Bible, and was prompted by that love to commit large portions of it to memory. Later on I became adroit in turning my Scriptural knowledge against the Church of Rome; but the characteristic doctrines of that Church marked only for a time the limits of inquiry. The eternal Sonship of Christ, for example, as enunciated in the Athanasian Creed, perplexed me. The resurrection of the body was also a thorn in my mind, and here I remember that a passage in Blair's "Grave" gave me momentary rest:

> ". . . . Sure the same power
> That rear'd the piece at first and took it down
> Can reassemble the loose, scatter'd parts
> And put them as they were."

The conclusion seemed for the moment entirely fair, but, with further thought, my difficulties came back to me. I had seen cows and sheep browsing upon churchyard grass, which sprang from the decaying mould of dead men. The flesh of these animals was undoubtedly a modification of human flesh, and the persons who fed upon them were as undoubtedly, in part, a more remote modification of the same substance. I figured the self-same molecules as belonging first to one body and afterward to a different one, and asked myself how two bodies so related could possibly arrange their claims at the day of resurrection. The scattered parts of each were to be reassembled and set as they were. But, if handed over to the one, how could they possibly enter into the composition of the other? Omnipotence itself, I concluded, could not reconcile the contradiction. Thus the plank which Blair's mechanical theory of the resurrection brought momentarily into sight disappeared, and I was again cast abroad on the waste ocean of speculation.

At the same time I could by no means get rid of the idea that the aspects of Nature and the consciousness of man implied the operation of a power altogether beyond my grasp—an energy the thought of

[1] "Natural History of Atheism," p. 125.

which raised the temperature of the mind, though it refused to accept shape, personal or otherwise, from the intellect. Perhaps the able critics of the *Saturday Review* are justified in speaking as they sometimes do of Mr. Carlyle. They owe him nothing, and have a right to announce the fact in their own way. I, on the other hand, owe him a great deal, and am also in honor bound to acknowledge the debt. Few, perhaps, who are privileged to come into contact with that illustrious man have shown him a sturdier front than I have, or in discussing modern science have more frequently withstood him. But I could see that his contention at bottom always was that the human soul has claims and yearnings which physical science cannot satisfy. England to come will assuredly thank him for his affirmation of the ethical and ideal side of human nature. Be this as it may, at the period now reached in my story, the feeling above referred to was indefinitely strengthened, my whole life being at the same time rendered more earnest, resolute, and laborious, by the writings of Carlyle. In this relation I cared little for political theories or philosophic systems, but I cared a great deal for the propagated life and strength of pure and powerful minds. At school I had picked up some mathematics and physics; my stock of both was, however, scanty, and I resolved to augment it. But it was really with the view of learning whether mathematics and physics could help me in other spheres, rather than with the desire of acquiring distinction in either science, that I resolved, in 1848, to break the continuity of my life, and to devote the meagre funds I had then collected to the study of science in Germany.

But science soon fascinated me on its own account; and I could see that, to carry it duly and honestly out, moral qualities were incessantly invoked. There was no room allowed for insincerity—no room even for carelessness. The edifice of science had been raised by men who had unswervingly followed the truth as it is in Nature; and in doing so had often sacrificed interests which are usually potent in this world. Among these rationalistic men of Germany conscientiousness in work was as much insisted on as it could be among theologians. And why, since they had not the rewards or penalties of the theologian to offer to their disciples? Because they assumed, and were justified in assuming, that those whom they addressed had that within them which would respond to their appeal. If Germany should ever change for something less noble the simple earnestness and fidelity to duty which in those days characterized her teachers, and through them her sons generally, it will not be because of rationalism. Such a decadent Germany might coexist with the most rampant rationalism without their standing to each other in the relation of cause and effect.

My first really laborious investigation landed me in a region which harmonized with my speculative tastes. It was essentially an inquiry in molecular physics, having reference to the curious, and then perplexing, phenomena exhibited by crystals when freely suspended in the

magnetic field. I here lived amid the most complex operations of magnetism in its twofold aspect of an attractive and a repellent force. Iron was attracted by a magnet, bismuth was repelled, and the crystals operated on ranged themselves under these two heads. Faraday and Plücker had worked assiduously at the subject, and had invoked the aid of new forces to account for the phenomena. It was soon, however, found that the displacement, in a crystal, of an atom of the iron class by an atom of the bismuth class, without any change of crystalline form, produced a complete reversal of the phenomena. The lines through the crystal which were in the one case drawn toward the poles of the magnet, were driven in the other case from these poles. By such instances and the reasoning which they suggested, magne-crystallic action was proved to be due, not to the operation of new forces, but to the modification of the old ones by molecular arrangement. Whether diamagnetism, like magnetism, was a polar force, was in those days a subject of the most lively contention. It was finally proved to be so; and the most complicated cases of magne-crystallic action were immediately shown to be simple mechanical consequences of the principle of diamagnetic polarity. These early researches, which occupied in all five years of my life, and during which the molecular architecture of crystals was an incessant subject of mental contemplation, gave a tinge and bias to my subsequent scientific thought, and their influence is easily traced in my subsequent inquiries. For example, during nine long years of labor on the subject of radiation, heat and light were handled throughout by me, not as ends, but as instruments by the aid of which the mind might perchance lay hold upon the ultimate particles of matter.

Scientific progress depends on two factors which incessantly interact—the strengthening of the mind by exercise and the illumination of phenomena by knowledge. There seems no limit to the insight regarding physical processes which this interaction carries in its train. Through such insight we are enabled to enter and explore that subsensible world into which all natural phenomena strike their roots, and from which they derive nutrition. By it we are enabled to place before the mind's eye atoms and atomic motions which lie far beyond the range of the senses, and to apply to them reasoning as stringent as that applied by the mechanician to the motions and collisions of sensible masses. But, once committed to such conceptions, there is the risk of being led irresistibly beyond the bounds of inorganic Nature. Even in these early stages of scientific development I found myself more and more compelled to regard not only crystals, but organic structures, the body of man inclusive, as cases of molecular architecture, infinitely more complex, it is true, than those of inorganic Nature, but reducible, in the long-run, to the same mechanical laws. In ancient journals I find recorded ponderings and speculations relating to these subjects, and attempts made, by reference to magnetic and crystalline phenomena, to present some satisfactory image to the mind of the way in which plants and animals are

built up. Perhaps I may be excused for noting a sample of these early speculations, already possibly known to a few of my readers, but which here finds a more suitable place than that which it formerly occupied.

Sitting, in the summer of 1855, with my friend Dr. Debus under the shadow of a massive elm on the bank of a river in Normandy, the current of our thoughts and conversation was substantially this: We regarded the tree above us. In opposition to gravity its molecules had ascended, diverged into branches, and budded into innumerable leaves. What caused them to do so—a power external to themselves, or an inherent force? Science rejects the outside builder; let us, therefore, consider from the other point of view the experience of the present year. A low temperature had kept back for weeks the life of the vegetable world. But at length the sun gained power—or, rather, the cloud-screen which our atmosphere had drawn between him and us was removed—and life immediately kindled under his warmth. But what is life, and how can solar light and heat thus affect it? Near our elm was a silver-birch, with its leaves rapidly quivering in the morning air. We had here motion, but not the motion of life. Each leaf moved as a mass under the influence of an outside force, while the motion of life was inherent and molecular. How are we to figure this molecular motion—the forces which it implies, and the results which flow from them? Suppose the leaves to be shaken from the birch-tree and enabled to attract and repel each other. To fix the ideas, suppose the point of each leaf to repel all other points and to attract the other ends, and the root of each leaf to repel all other roots, but to attract the points. The leaves would then resemble an assemblage of little magnets abandoned freely to the interaction of their own forces. In obedience to these they would arrange themselves, and finally assume positions of rest, forming a coherent mass. Let us suppose the breeze, which now causes them to quiver, to disturb the assumed equilibrium. As often as disturbed there would be a constant effort on the part of the leaves to reestablish it; and in making this effort the mass of leaves would pass through different shapes and forms. If other leaves, moreover, were at hand endowed with similar forces, the action would extend to them—a growth of the mass of leaves being the consequence.

We have strong reason for assuming that the ultimate particles of matter—the atoms and molecules of which it is made up—are endowed with forces coarsely typified by those here ascribed to the leaves. The phenomena of crystallization lead, of necessity, to this conception of molecular polarity. Under the operation of such forces the molecules of a seed, like our fallen leaves in the first instance, take up positions from which they would never move if undisturbed by an external impulse. But solar light and heat, which come to us as waves through space, are the great agents of molecular disturbance. On the inert molecules of seed and soil these waves impinge, disturbing the atomic

equilibrium, which there is an immediate effort to restore. The effort, incessantly defeated—for the waves continue to pour in—is incessantly renewed; in the molecular struggle, matter is gathered from the soil and from the atmosphere, and built, in obedience to the forces which guide the molecules, into the special form of the tree. In a general way, therefore, the life of the tree might be defined as an unceasing effort to restore a disturbed equilibrium. In the building of crystals, Nature makes her first structural effort; we have here the earliest groping of the so-called "vital force," and the manifestations of this force in plants and animals, though, as already stated, indefinitely more complex, are to be regarded of the same mechanical quality as those concerned in the building of the crystal.

Consider the cycle of operations by which the seed produces the plant, the plant the flower, the flower again the seed, the causal line returning with the fidelity of a planetary orbit to its original point of departure. Who or what planned this molecular rhythm? We do not know—science fails even to inform us whether it was ever "planned" at all. Yonder butterfly has a spot of orange on its wing; and if we look at a drawing made a century ago, of one of the ancestors of that butterfly, we probably find the self-same spot upon the wing. For a century the molecules have described their cycles. Butterflies have been begotten, have been born, and have died; still we find the molecular architecture reproduced. Who or what determined this persistency of recurrence? We do not know; but we stand within our intellectual range when we say that there is probably nothing in that wing which may not yet find its Newton to prove that the principles involved in its construction are qualitatively the same as those brought into play in the formation of the solar system. We may even take a step further, and affirm that the brain of man—the organ of his reason and his sense—without which he can neither think nor feel—is also an assemblage of molecules, acting and reacting according to law. Here, however, the methods pursued in mechanical science come to an end; and if asked to deduce from the physical interaction of the brain-molecules the least of the phenomena of sensation or thought, we must acknowledge our helplessness. The association of both with the matter of the brain may be as certain as the association of light with the rising of the sun. But whereas in the latter case we have unbroken mechanical connection between the sun and our organs, in the former case logical continuity disappears. Between molecular mechanics and consciousness is interposed a fissure, over which the ladder of physical reasoning is incompetent to carry us. We must, therefore, accept the observed association as an empirical fact, without being able to bring it under the yoke of *a priori* deduction.

Such were the ponderings which ran habitually through my mind in the days of my scientific youth. They illustrate two things: a determi-

nation to push physical considerations to their utmost legitimate limit; and an acknowledgment that physical considerations do not lead to the final explanation of all that we feel and know. This acknowledgment, be it said in passing, was by no means made with the view of providing room for the play of considerations other than physical. The same intellectual duality, if I may use the phrase, manifests itself in the following extract from an article published in the *Saturday Review* for August 4, 1860:

"The philosophy of the future will assuredly take more account than that of the past of the dependence of thought and feeling on physical processes; and it may be that the qualities of the mind will be studied through organic combinations as we now study the character of a force through the affections of ordinary matter. We believe that every thought and every feeling has its definite mechanical correlative—that it is accompanied by a certain breaking up and remarshaling of the atoms of the brain. This latter process is purely physical; and, were the faculties we now possess sufficiently expanded, without the creation of any new faculty, it would doubtless be within the range of our augmented powers to infer from the molecular state of the brain the character of the thought acting on it, and conversely to infer from the thought the exact molecular condition of the brain. We do not say—and this, as will be seen, is all-important—that the inference here referred to would be an *a priori* one. But by observing, with the faculties we assume, the state of the brain, and the associated mental affections, both might be so tabulated side by side that, if one were given, a mere reference to the table would declare the other. Our present powers, it is true, shrivel into nothingness when brought to bear on such a problem, but it is because of its complexity and our limits that this is the case. The *quality* of the problem and of our powers are, we believe, so related that a mere expansion of the latter would enable them to cope with the former. Why, then, in scientific speculation should we turn our eyes exclusively to the past? May it not be that a time is coming—ages no doubt distant, but still advancing—when the dwellers upon this earth, starting from the gross human brain of to-day as a rudiment, may be able to apply to these mighty questions faculties of commensurate extent? Given the requisite expansibility to the present senses and intelligence of man—given also the time necessary for their expansion—and this high goal may be attained. Development is all that is required, and not a change of quality. There need be no absolute breach of continuity between us and our loftier brothers yet to come.

"We have guarded ourselves against saying that the inferring of thought from material combinations and arrangements would be an inference *a priori*. The inference meant would be the same in kind as that which the observation of the effects of food and drink upon the mind would enable us to make, differing only from the latter in the degree of analytical insight which we suppose attained. Given the masses and distances of the planets, we can infer the perturbations consequent on their mutual attractions. Given the nature of a disturbance in water, air, or ether—knowing the physical qualities of the medium—we can infer how its particles will be affected. In all this we deal with physical laws. The mind runs with certainty along the line of thoughts which connect the phenomena, and from beginning to end there is no break in the chain. But when we endeavor to pass by a similar process from the phenomena of physics to those of thought, we meet a problem which transcends any conceiv-

able expansion of the powers which we now possess. We may think over the subject again and again, but it eludes all intellectual presentation. The territory of physics is wide, but it has its limits from which we look with vacant gaze into the region beyond. Let us follow matter to its utmost bounds, let us claim it in all its forms—even in the muscles, blood, and brain of man himself, it is ours to experiment with and to speculate upon. Casting the term 'vital force' from our vocabulary, let us reduce, if we can, the visible phenomena of life to mechanical attractions and repulsions. Having thus exhausted physics, and reached its very rim, a mighty mystery still looms beyond us. We have, in fact, made no step toward its solution. And thus it will ever loom, compelling the philosophies of successive ages to confess that—

> . . . . 'we are such stuff
> As dreams are made of, and our little life
> Is rounded by a sleep.'"

In my work on "Heat," first published in 1863, I employ the precise language here extracted from the *Saturday Review*.

In this extract a distinction is revealed which I had resolved at all hazards to draw—that, namely, between what men knew or might know, and what they could never hope to know. Impart simple magnifying power to our present vision, and the atomic motions of the brain itself might be brought into view. Compare these motions with the corresponding states of consciousness, and an empirical nexus might be established; but "we try to soar in a vacuum when we endeavor to pass by logical deduction from the one to the other." Among those brain-effects a new product appears which defies mechanical treatment. We cannot deduce consciousness from motion, or motion from consciousness, as we deduce one motion from another. Nevertheless observation is open to us, and by it relations may be established which are at least as valid as the conclusions of deductive reason. The difficulty may really lie in the attempt to convert a datum into an inference—an ultimate fact into a product of logic. My desire for the moment, however, is, not to theorize, but to let fact speak in reply to accusation.

The most "materialistic" speculation for which I am responsible, prior to the "Belfast Address," is embodied in the following extract from a brief article written as far back as 1865:

> "Supposing the molecules of the human body, instead of replacing others, and thus renewing a preëxisting form, to be gathered first-hand from Nature, and placed in the exact relative positions which they occupy in the body. Supposing them to have the same forces and distribution of forces, the same motions and distribution of motions—would this organized concourse of molecules stand before us as a sentient, thinking being? There seems no valid reason to assume that it would not. Or, supposing a planet carved from the sun set spinning round an axis, and sent revolving round the sun at a distance equal to that of our earth, would one consequence of the refrigeration of the mass be the development of organic forms? I lean to the affirmative."

This may be plain speaking, but it is without "dogmatism." An opinion is expressed, a belief, a *leaning*—not an established "doctrine."

The burden of my writings in this connection is as much a recognition of the weakness of science as an assertion of its strength. In 1867 I told the working-men of Dundee that while making the largest demand for freedom of investigation; while considering science to be alike powerful as an instrument of intellectual culture, and as a ministrant to the material wants of men—if asked whether science has solved, or is likely in our day to solve, "the problem of the universe," I must shake my head in doubt. I compare the mind of man to a musical instrument with a certain range of notes, beyond which in both directions exists infinite silence. The phenomena of matter and force come within our intellectual range; but behind, and above, and around us, the real mystery of the universe lies unsolved, and, as far as we are concerned, is incapable of solution.

While refreshing my mind on these old themes I am struck by the poverty of my own thought; appearing to myself as a person possessing one idea, which so overmasters him that he is never weary of repeating it. That idea is the polar conception of the grandeur and the littleness of man—the vastness of his range in some respects and directions, and his powerlessness to take a single step in others. In 1868, before the mathematical and physical section of the British Association, then assembled at Norwich, I repeat the same well-worn note:

"In affirming the growth of the human body to be mechanical, and thought as exercised by us to have its correlative in the physics of the brain, the position of the 'materialist,' as far as that position is tenable, is stated. I think the materialist will be able finally to maintain this position against all attacks, but I do not think he can pass beyond it. The problem of the connection of body and soul is as insoluble in its modern form as it was in the prescientific ages. Phosphorus is a constituent of the human brain, and a trenchant German writer has exclaimed, 'Ohne Phospor kein Gedanke!' That may or may not be the case; but, even if we knew it to be the case, the knowledge would not lighten our darkness. On both sides of the zone here assigned to the materialist, he is equally helpless. If you ask him whence is this 'matter,' of which we have been discoursing—who or what divided it into molecules, and impressed upon them this necessity of running into organic forms—he has no answer. Science is also mute in regard to such questions. But if the materialist is confounded, and Science is rendered dumb, who else is prepared with an answer? Let us lower our heads and acknowledge our ignorance, priest and philosopher, one and all."

The roll of echoes which succeeded the lecture delivered by Prof. Virchow at Munich on September 22, 1877, was long and loud. The *Times* published a nearly full translation of the lecture, and it was eagerly commented on in other journals. Glances from it to an address delivered by me before the Midland Institute last autumn were very frequent. Prof. Virchow was held up to me in some quarters as a model of philosophic caution, who by his reasonableness reproved my rashness and by his depth reproved my shallowness. With true theologic courtesy I was sedulously emptied not only of "the principles of

scientific thought," but of "common modesty" and "common sense." And, though I am indebted to Prof. Clifford for recalling in the *Nineteenth Century* for April the public mind in this connection from heated fancy to sober fact, I do not think a brief additional examination of Virchow's views, and of my relation to them, will be out of place here.

The key-note of his position is struck in the preface to the excellent English translation of his lecture—a preface written expressly by himself. Nothing, he says, was further from his intention than any wish to disparage the great services rendered by Mr. Darwin to the advancement of biological science, of which no one has expressed more admiration than himself. On the other hand, it seemed high time to him to enter an energetic protest against the attempts that are made to proclaim the problems of research as actual facts, and the opinions of scientists as established science. On the ground, among others, that it promotes the pernicious delusions of the socialists, Virchow considers the theory of evolution dangerous ; but his fidelity to truth is so great that he would brave the danger and teach the theory, if it were only proved. The burden indeed of this celebrated lecture is a warning that a marked distinction ought to be made between that which is experimentally established, and that which is still in the region of speculation. As to the latter, Virchow by no means imposes silence. He is far too sagacious a man to commit himself, at the present time of day, to any such absurdity. But he insists that it ought not to be put on the same evidential level as the former. "It ought," as he poetically expresses it, "to be written in small letters under the text." The audience ought to be warned that the speculative matter is only *possible*, not *actual* truth—that it belongs to the region of "belief," and not to that of demonstration. As long as a problem continues in this speculative stage it would be mischievous, he considers, to teach it in our schools. "We ought not," he urges, "to represent our conjecture as a certainty, nor our hypothesis as a doctrine : this is inadmissible." With regard to the connection between physical processes and mental phenomena he says: "I will, indeed, willingly grant that we can find certain gradations, certain definite points at which we trace a passage from mental processes to processes purely physical, or of a physical character. Throughout this discourse I am not asserting that it will never be possible to bring psychical processes into an immediate connection with those that are physical. All I say is, that we have *at present* no right to set up this *possible* connection as a doctrine of science." In the next paragraph he reiterates his position with reference to the introduction of such topics into school-teaching. "We must draw," he says, "a strict distinction between what we wish to *teach* and what we wish to *search for*. The objects of our research are expressed as problems (or hypotheses). *We need not keep them to ourselves ; we are ready to communicate them to all the world*, and say, 'There is the problem ; that is what we strive for.' . . . The investigation of such problems,

in which the whole nation may be interested, cannot be restricted to any one. This is freedom of inquiry. But the problem (or hypothesis) is not, without further debate, to be made *a doctrine*." He will not concede to Dr. Haeckel "that it is a question for the schoolmasters to decide, whether the Darwinian theory of man's descent should be at once laid down as the basis of instruction, and the protoplastic soul be assumed as the foundation of all ideas concerning spiritual being." The professor concludes his lecture thus: "With perfect truth did Bacon say of old, '*Scientia est potentia.*' But he also defined that knowledge; and the knowledge he meant was not speculative knowledge, not the knowledge of hypotheses, but it was objective and actual knowledge. Gentlemen, I think we should be abusing our power, we should be imperiling our power, unless in our teaching we restrict ourselves to this perfectly safe and unassailable domain. From this domain *we may make incursions into the field of problems*, and I am sure that every venture of that kind will then find all needful security and support." I have emphasized by italics two sentences in the foregoing series of quotations; the other italics are the author's own.

Virchow's position could not be made clearer by any comments of mine than he has here made it himself. That position is one of the highest practical importance. "Throughout our whole German Fatherland," he says, "men are busied in renovating, extending, and developing the system of education, and in inventing fixed forms in which to mould it. On the threshold of coming events stands the Prussian law of education. In all the German states larger schools are being built, new educational establishments are set up, the universities are extended, 'higher' and 'middle' schools are founded. Finally comes the question, 'What is to be the chief substance of the teaching?'" What, in regard to science, Virchow thinks it ought and ought not to be, is disclosed by the foregoing quotations. There ought to be a clear distinction made between science in the state of hypothesis and science in the state of fact. From school-teaching the former ought to be excluded. And, inasmuch as it is still in its hypothetical stage, the ban of exclusion ought to fall upon the theory of evolution.

I now freely offer myself for judgment before the tribunal whose law is here laid down. First and foremost, then, I have never advocated the introduction of the theory of evolution into our schools. I should even be disposed to resist its introduction before its meaning had been better understood and its utility more fully recognized than it is now by the great body of the community. The theory ought, I think, to bide its time until the free conflict of discovery, argument, and opinion, has won for it this recognition. In dealing with the community great changes must have *timeliness* as well as truth upon their side. But, if the mouths of thinkers are stopped, the necessary social preparation will be impossible; an unwholesome divorce will be estab-

lished between the expert and the public, and the slow and natural process of leavening the social lump by discovery and discussion will be displaced by something far less safe and salutary. On this count, then, I claim acquittal, being for the moment on the side of Virchow.

In a discourse delivered before the British Association at Liverpool, after speaking of the theory of evolution applied to the primitive condition of matter as belonging to "the dim twilight of conjecture," and affirming that "the certainty of experimental inquiry is here shut out," I sketch the nebular theory as enunciated by Kant and Laplace, and afterward proceed thus:

> "Accepting some such view of the construction of our system as *probable*, a desire immediately arises to connect the present life of our planet with the past. We wish to know something of our remotest ancestry. On its first detachment from the sun, life, as we understand it, could not have been present on the earth. How, then, did it come there? The thing to be encouraged here is a reverent freedom—a freedom preceded by the hard discipline which checks licentiousness in speculation—while the thing to be repressed, both in science and out of it, is dogmatism. And here I am in the hands of the meeting, willing to end but ready to go on. *I have no right to intrude upon you unasked the unformed notions which are floating like clouds or gathering to more solid consistency in the modern speculative mind.*"

I then notice more especially the theory of evolution:

> "Those who hold the doctrine of evolution *are by no means ignorant of the uncertainty of their data, and they only yield to it a provisional assent.* They regard the nebular hypothesis as probable; and, in the utter absence of any proof of the illegality of the act, they prolong the method of Nature from the present into the past. Here the observed uniformity of Nature is their only guide. Having determined the elements of their curve in a world of observation and experiment, they prolong that curve into an antecedent world, and accept as probable the unbroken sequence of development from the nebula to the present time."

Thus it appears that, long antecedent to the publication of his advice, I did exactly what Prof. Virchow recommends, showing myself as careful as he could be not to claim for a scientific doctrine a certainty which did not belong to it.

I now pass on to the "Belfast Address," and will cite at once from it the passage which has given rise to the most violent animadversion:

> "Believing as I do in the continuity of Nature, I cannot stop abruptly where our microscopes cease to be of use. At this point the vision of the mind authoritatively supplements that of the eye. By an intellectual necessity I cross the boundary of the experimental evidence, and discern in that 'matter' which we, in our ignorance of its latent powers, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of all terrestrial life."

Without halting for a moment I go on to do the precise thing which Prof. Virchow declares to be necessary:

"If you ask me whether there exists the least evidence to prove that any form of life can be developed out of matter independently of antecedent life, my reply is that evidence considered perfectly conclusive by many has been adduced, and that were we to follow a common example, and accept testimony because it falls in with our belief, we should eagerly close with the evidence referred to. But those to whom I refer as having studied this question, believing the evidence offered in favor of 'spontaneous generation' to be vitiated by error, cannot accept it. They know full well that the chemist now prepares from inorganic matter a vast array of substances, which were some time ago regarded as the products solely of vitality. They are intimately acquainted with the structural power of matter, as evidenced in the phenomena of crystallization. They can justify scientifically their *belief* in its potency, under the proper conditions, to produce organisms. But, in reply to your question, they will frankly admit their inability to point to any satisfactory experimental proof that life can be developed, save from demonstrable antecedent life." [1]

Three years subsequently it fell to my lot to address the members of the Midland Institute at Birmingham, and a very few words will reveal the grounds of my reference on that occasion to the "Theory of Descent." "Ten years have elapsed," said Dr. Hooker at Norwich in 1868,[2] "since the publication of 'The Origin of Species by Natural Selection,' and it is therefore not too early now to ask what progress that bold theory has made in scientific estimation. Since the 'Origin' appeared it has passed through four English editions,[3] two American, two German, two French, several Russian, a Dutch, and an Italian. So far from Natural Selection being a thing of the past (the *Athenæum* had stated it to be so), it is an accepted doctrine with almost every philosophical naturalist, including, it will always be understood, a considerable proportion who are not prepared to admit that it accounts for all Mr. Darwin assigns to it." In the following year, at Innspruck, Helmholtz took up the same ground. Another decade has now passed, and he is simply blind who cannot see the enormous progress made by the theory during that time. Some of the outward and visible signs of this advance are readily indicated. The hostility and fear which so long prevented the recognition of Mr. Darwin by his own university have vanished, and this year Cambridge, amid universal acclamation, conferred on him her Doctor's degree. The Academy of Sciences in Paris, which had so long persistently closed its doors against him, has also yielded at last; while sermons, lectures, and published articles, plainly show that even the clergy have, to a great extent, become acclimatized to the Darwinian air. My reference to Mr. Darwin in the Birmingham Address was based upon the knowledge that such changes had been accomplished, and were still going on.

That the lecture of Prof. Virchow can to any practical extent dis-

[1] Quoted by Clifford, *Nineteenth Century*, iii., p. 726.

[2] President's Address to the British Association.

[3] Published by Mr. John Murray, the English publisher of Virchow's lecture. Bane and antidote are thus impartially distributed by the same hand.

turb this progress of public faith in the theory of evolution, I do not believe. That the special lessons of caution which he inculcates were exemplified by me, years before his voice was heard upon this subject, has been proved in the foregoing pages. It is possible to draw the coincident lines still further, for most of what he has said about spontaneous generation might have been uttered by me. I share his opinion that the theory of evolution in its complete form involves the assumption that at some period or other of the earth's history there occurred what would be now called "spontaneous generation." I agree with him that "the proofs of it are still wanting. . . . Whoever," he says, "recalls to mind the lamentable failure of all the attempts made very recently to discover a decided support for the *generatio æquivoca* in the lower forms of transition from the inorganic to the organic world will feel it doubly serious to demand that this theory, so utterly discredited, should be in any way accepted as the basis of all our views of life." I hold with Virchow that the failures *have* been lamentable, that the doctrine *is* utterly discredited. But my position here is so well known that I need not dwell upon it further.

With one special utterance of Prof. Virchow his translator connects me by name. "I have no objection," observes the professor, "to your saying that atoms of carbon also possess mind, or that in their connection with the Plastidule company they acquire mind; only *I do not know how I am to perceive this.*" This is substantially what I had said seventeen years previously in the *Saturday Review*. The professor continues: "If I explain attraction and repulsion as exhibitions of mind, as psychical phenomena, I simply throw the Psyche out of the window, and the Psyche ceases to be a Psyche." I may say, in passing, that the Psyche that *could* be cast out of the window is not worth house-room. At this point the translator, who is evidently a man of culture, strikes in with a foot-note: "As an illustration of Prof. Virchow's meaning, we may quote the conclusion at which Dr. Tyndall arrives respecting the hypothesis of a human soul, offered as an explanation or a simplification of a series of obscure phenomena—psychical phenomena, as he calls them. 'If you are content to make your soul a poetic rendering of a phenomenon which refuses the yoke of ordinary physical laws, I, for one, would not object to this exercise of ideality.'"[1] Prof. Virchow's meaning, I admit, required illustration; but I do not clearly see how the quotation from me subserves this purpose. I do not even know whether I am cited as meriting praise or deserving opprobrium. In a far coarser fashion this utterance of mine has been dealt with in another place: it may therefore be worth while to spend a few words upon it.

The sting of a wasp at the finger-end announces itself to the brain as pain. The impression made by the sting travels, in the first place,

[1] Presidential Address delivered before the Birmingham and Midland Institute, October 1, 1877. *Fortnightly Review*, November 1, 1877, p. 607.

with comparative slowness along the nerves affected; and only when it reaches the brain have we the fact of consciousness. Those who think most profoundly on this subject hold that a chemical change, which, strictly interpreted, is atomic motion, is, in such a case, propagated along the nerve, and communicated to the brain. Again, on feeling the sting I flap the insect violently away. What has caused this motion of my hand? The command to remove the insect travels from the brain along the motor nerves to the proper muscles, and, their force being unlocked, they perform the work demanded of them. But what moved the nerve-molecules which unlocked the muscle? The sense of pain, it may be replied. But how can a sense of pain, or any other state of consciousness, make matter move? Not all the sense of pain or pleasure in the world could lift a stone or move a billiard-ball; why should it stir a molecule? Try to express the motion numerically in terms of the sensation, and the difficulty immediately appears. Hence the idea long ago entertained by philosophers, but lately brought into special prominence, that the physical processes are complete in themselves, and would go on just as they do if consciousness were not at all implicated. Consciousness, on this view, is a kind of by-product inexpressible in terms of force and motion, and unessential to the molecular changes going on in the brain.

Four years ago I wrote thus:

> "Do states of consciousness enter as links into the chain of antecedence and sequence which gives rise to bodily actions? Speaking for myself, it is certain that I have no power of imagining such states interposed between the molecules of the brain, and influencing the transference of motion among the molecules. The thing 'eludes all mental presentation.' Hence an iron strength seems to belong to the logic which claims for the brain an automatic action uninfluenced by consciousness. But it is, I believe, admitted, by those who hold the automaton theory, that consciousness is *produced* by the motion of the molecules of the brain; and this production of consciousness by molecular motion is to me quite as unpresentable to the mental vision as the production of molecular motion by consciousness. If I reject one result I must reject both. *I, however, reject neither*, and thus stand in the presence of two incomprehensibles instead of one incomprehensible."

Here I secede from the automaton theory, though maintained by friends who have all my esteem, and fall back upon the avowal which occurs with such wearisome iteration throughout the foregoing pages; namely, my own utter incapacity to grasp the problem.

This avowal is repeated with emphasis in the passage to which Prof. Virchow's translator draws attention. What, I there ask, is the causal connection between the objective and the subjective—between molecular motions and states of consciousness? My answer is: I do not see the connection, nor am I acquainted with anybody who does. It is no explanation to say that the objective and subjective are two sides of one and the same phenomenon. Why should the phenomenon

have two sides? This is the very core of the difficulty. There are plenty of molecular motions which do not exhibit this two-sideness. Does water think or feel when it runs into frost-ferns upon a window-pane? If not, why should the molecular motion of the brain be yoked to this mysterious companion—consciousness? We can form a coherent picture of all the purely physical processes—the stirring of the brain, the thrilling of the nerves, the discharging of the muscles, and all the subsequent motions of the organism. We are here dealing with mechanical problems which are mentally presentable. But we can form no picture of the process whereby consciousness emerges either as a necessary link or as an accidental by-product of this series of actions. The reverse process of the production of motion by consciousness is equally unpresentable to the mind. We are here, in fact, on the boundary-line of the intellect, where the ordinary canons of science fail to extricate us from difficulty. If we are true to these canons, we must deny to subjective phenomena all influence on physical processes. The mechanical philosopher, *as such*, will never place a state of consciousness and a group of molecules in the relation of mover and moved. Observation proves them to interact; but, in passing from the one to the other, we meet a blank which the logic of deduction is unable to fill. This, the reader will remember, is the conclusion at which I had arrived more than twenty years ago. I lay bare unsparingly the central difficulty of the materialist, and tell him that the facts of observation which he considers so simple are "almost as difficult to be seized mentally as the idea of a soul." I go further, and say, in effect, to those who wish to retain this idea, "If you abandon the interpretations of grosser minds, who image the soul as a Psyche which could be thrown out of the window—an entity which is usually occupied, we know not how, among the molecules of the brain, but which on due occasion, such as the intrusion of a bullet or the blow of a club, can fly away into other regions of space—if, abandoning this heathen notion, you approach the subject in the only way in which approach is possible—if you consent to make your soul a poetic rendering of a phenomenon which, as I have taken more pains than anybody else to show you, refuses the yoke of ordinary physical laws—then I, for one, would not object to this exercise of ideality." I say it strongly, but with good temper, that the theologian, or the defender of theology, who hacks and scourges me for putting the question in this light is guilty of black ingratitude.

Notwithstanding the agreement thus far pointed out, there are certain points in Prof. Virchow's lecture to which I should feel inclined to take exception. I think it was hardly necessary to associate the theory of evolution with socialism; it may be even questioned whether it was correct to do so. As Lange remarks, the aim of socialism, or of its extreme leaders, is to overthrow the existing systems of government,

and anything that helps them to this end is welcomed, whether it be atheism or papal infallibility. For long years the Socialists saw church and state united against them, and both were therefore regarded with a common hatred. But no sooner does a serious difference arise between church and state, than a portion of the Socialists begin immediately to dally with the former.[1] The experience of the last German elections illustrates Lange's position. Far nobler and truer to my mind than this fear of promoting socialism by a scientific theory which the best and soberest heads in the world have substantially accepted, is the position assumed by Helmholtz, who in his "Popular Lectures" describes Darwin's theory as embracing "an essentially new creative thought" (einen wesentlich neuen schöpferischen Gedanken), and who illustrates the greatness of this thought by copious references to the solutions, previously undreamed of, which it offers of the enigmas of life and organization. One point in this "popular" exposition deserves especial mention here. Helmholtz refers to the dominant position acquired by Germany in physiology and medicine, while other nations have kept abreast of her in the investigation of inorganic Nature. He claims for German men the credit of pursuing with unflagging zeal and self-denying industry, guided by ideal aims, and without any immediate prospect of practical utility, the cultivation of pure science. But that which has determined German superiority in the fields referred to was, in his opinion, something different from this. Inquiries as to the nature of life are intimately connected with psychological and ethical questions; and he claims for his countrymen a greater fearlessness of the consequences which a full knowledge of the truth may here carry along with it than reigns among the inquirers of other nations. Helmholtz points to the cause of this timidity:

"England and France possess distinguished investigators—men competent to follow up and illustrate with vigorous energy the methods of natural science; but they have hitherto been compelled to bend before social and theological prejudices, and could only utter their convictions under the penalty of injuring their social influence and usefulness. Germany has gone forward more courageously. She has cherished the trust, which has never been deceived, that complete truth carries with it the antidote against the bane and danger which follow in the train of half-knowledge. A cheerfully laborious and temperate people—a people morally strong—can well afford to look truth full in the face. Nor are they to be ruined by the enunciation of one-sided theories, even when these may appear to threaten the bases of society."

These words of Helmholtz are, in my opinion, wiser and more applicable to the condition of Germany at the present moment than those which express the fears of Prof. Virchow. It will be remembered that at the time of his lecture his chief anxiety was directed toward France; but France has since that time given ample evidence of her ability to

[1] "Geschichte des Materialismus," zweite Aufl., vol. ii., p. 538.

crush, not only Socialists, but anti-Socialists, who would impose on her a yoke which she refuses to bear.

In close connection with these utterances of Helmholtz, I place another utterance not less noble, which I trust was understood and appreciated by those to whom it was addressed:

"If" (said the President of the British Association in his opening address in Dublin) "we could lay down beforehand the precise limits of possible knowledge, the problem of physical science would be already half solved. But the question to which the scientific explorer has often to address himself is not merely whether he is able to solve this or that problem, but whether he can so far unravel the tangled threads of the matter with which he has to deal as to weave them into a definite problem at all. . . . If his eye seem dim, he must look steadfastly and with hope into the misty vision, until the very clouds wreath themselves into definite forms. If his ear seem dull, he must listen patiently and with sympathetic trust to the intricate whisperings of Nature—the goddess, as she has been called, of a hundred voices—until here and there he can pick out a few simple notes to which his own powers can resound. If, then, at a moment when he finds himself placed on a pinnacle from which he is called upon to take a perspective survey of the range of science, and to tell us what he can see from his vantage-ground; if at such a moment, after straining his gaze to the very verge of the horizon, and after describing the most distant of well-defined objects, he should give utterance also to some of the subjective impressions which he is conscious of receiving from regions beyond; if he should depict possibilities which seem opening to his view; if he should explain why he thinks this a mere blind alley and that an open path—*then the fault and the loss would be alike ours if we refused to listen calmly, and temperately to form our own judgment on what we hear; then assuredly it is we who would be committing the error of confounding matters of fact with matters of opinion, if we failed to discriminate between the various elements contained in such a discourse, and assumed that they had been all put on the same footing.*"

While largely agreeing with him, I cannot quite accept the setting in which Prof. Virchow places the confessedly abortive attempts to secure an experimental basis for the doctrine of spontaneous generation. It is not a doctrine "so discredited" that some of the scientific thinkers of England accept "as the basis of all their views of life." Their induction is by no means thus limited. They have on their side more than the "reasonable probability" deemed sufficient by Bishop Butler for practical guidance in the gravest affairs, that the members of the solar system which are now discrete once formed a continuous mass; that in the course of untold ages, during which the work of condensation went on through the waste of heat in space, the planets were detached; and that our present sun is the residual nucleus of the flocculent or gaseous ball from which the planets were successively separated. Life, as we define it, was not possible for æons subsequent to this separation. When and how did it appear? I have already pressed this question, but have received no answer.[1] If, with Prof. Knight, we

[1] In the "Apology for the Belfast Address," the question is reasoned out.

regard the Bible account of the introduction of life upon the earth as a poem, not as a statement of fact, where are we to seek for guidance as to the fact? There does not exist a barrier possessing the strength of a cobweb to oppose to the hypothesis which ascribes the appearance of life to that "potency of matter" which results in natural evolution.[1] This hypothesis is not without its difficulties, but they vanish when compared with those which encumber its rivals. There are various facts in science obviously connected, and whose connections we are unable to trace; but we do not think of filling the gap between them by the intrusion of a separable spiritual agent. In like manner, though we are unable to trace the course of things from the nebula, where there was no life in our sense, to the present earth where life abounds, the spirit and practice of science pronounce against the intrusion of an anthropomorphic creator. Theologians must liberate and refine their conceptions or be prepared for the rejection of them by thoughtful minds. It is they, not we, who lay claim to knowledge never given to man. "Our refusal of the creative hypothesis is less an assertion of knowledge than a protest against the assumption of knowledge which must long, if not always, lie beyond us, and the claim to which is a source of perpetual confusion." At the same time, when I look with strenuous gaze into the whole problem as far as my capacities allow, overwhelming wonder is the predominant feeling. This wonder has come to me from the ages just as much as my understanding, and it has an equal right to satisfaction. Hence I say, if, abandoning your illegitimate claim to knowledge, you place, with Job, your forehead in the dust and acknowledge the authorship of this universe to be past finding out—if, having made this confession, and relinquished the views of the mechanical theologian, you desire, for the satisfaction of feelings which I admit to be in great part those of humanity at large, to give ideal form to the Power that moves all things—it is not by me that you will find objections raised to this exercise of ideality, when consciously and worthily carried out.

Again, I think Prof. Virchow's position, in regard to the question of *contagium animatum*, is not altogether that of true philosophy. He points to the antiquity of the doctrine. "It is lost," he says, "in the darkness of the middle ages. We have received this name from our forefathers, and it already appears distinctly in the sixteenth century. We possess several works of that time which put forward *contagium animatum* as a scientific doctrine, with the same confidence, with the same sort of proof, with which the 'Plastidulic soul' is now set forth."

These speculations of our "forefathers" will appeal differently to different minds. By some they will be dismissed with a sneer; to

[1] "We feel it an undeniable necessity," says Prof. Virchow, "not to sever the organic world from the whole, as if it were something disjoined from the whole." This grave statement cannot be weakened by the subsequent pleasantry regarding "Carbon & Co."

others they will appear as proofs of genius on the part of those who enunciated them. There are men, and by no means the minority, who, however wealthy in regard to facts, can never rise into the region of principles; and they are sometimes intolerant of those who can. They are formed to plod meritoriously on the lower levels of thought, unpossessed of the pinions necessary to reach the heights. They cannot realize the mental act—the act of inspiration it might well be called—by which a man of genius, after long pondering and proving, reaches a theoretic conception which unravels and illuminates the tangle of centuries of observation and experiment. There are minds, it may be said in passing, who at the present moment stand in this relation to Mr. Darwin. For my part, I should be inclined to ascribe to penetration rather than to presumption the notion of a *contagium animatum*. He who invented the term ought, I think, to be held in esteem; for he had before him the quantity of fact and the measure of analogy that would justify a man of genius in taking a step so bold. "Nevertheless," says Prof. Virchow, "no one was able throughout a long time to discover these living germs of disease. The sixteenth century did not find them, nor did the seventeenth, nor the eighteenth." But it may be urged, in reply to this, that the theoretic conjecture often legitimately comes first. It is the forecast of genius which anticipates the fact and constitutes a spur toward its discovery. If instead of being a spur the theoretic guess rendered men content with imperfect knowledge, it would be a thing to be deprecated. But in modern investigation this is distinctly not the case; Darwin's theory, for example, like the undulatory theory, has been a motive power and not an anodyne. "At last," says Prof. Virchow, "in the nineteenth century we have begun little by little really to find *contagia animata*. So much the more honor is due to those who, three centuries in advance, so put together the facts and analogies of contagious disease as to divine its root and character. Prof. Virchow seems to deprecate the "obstinacy" with which this notion of a *contagium vivum* emerged. Here I should not be inclined to follow him; because I do not know, nor does he tell me, how much the discovery of facts in the nineteenth century is indebted to the stimulus derived from the theoretic discussions of preceding centuries. The genesis of scientific ideas is a subject of profound interest and importance. He would be but a poor philosopher who would sever modern chemistry from the efforts of the alchemists, who would detach modern atomic doctrines from the speculations of Lucretius and his predecessors, or who would claim for our present knowledge of contagia an origin altogether independent of the efforts of our "forefathers" to penetrate this enigma.

Finally, I do not know that I should agree with Prof. Virchow as to what a theory is or ought to be. I call a theory a principle or conception of the mind which accounts for observed facts, and which helps us to look for and predict facts not yet observed. Every new discovery

which fits into a theory strengthens it. The theory is not a thing complete from the first, but a thing which grows, as it were asymptotically, toward certainty. Darwin's theory, as pointed out nine or ten years ago by Helmholtz and Hooker, was then exactly in this condition of growth; and had they to speak of the subject to-day they would be able to announce an enormous strengthening of the theoretic fibre. Fissures in continuity which then existed, and which left little hope of being ever spanned, have been since bridged over, so that the further the theory is tested the more fully does it harmonize with progressive experience and discovery. We shall probably never fill all the gaps; but this will not prevent a profound belief in the truth of the theory from taking root in the general mind. Much less will it justify a total denial of the theory. The man of science who assumes in such a case the position of a denier is sure to be stranded and isolated. The proper attitude, in my opinion, is to give as nearly as possible to the theory during the phases of its growth a proportionate assent; and, if it be a theory which influences practice, our wisdom is to follow its *probable* suggestions where more than probability is for the moment unattainable. I write thus with the theory of *contagium vivum* more especially in my mind, and must regret the attitude of denial assumed by Prof. Virchow toward that theory. "I must beg my friend Klebs to pardon me," he says, "if, notwithstanding the late advances made by the doctrine of infectious fungi, I still persist in my reserve so far as to admit only the fungus which is really proved, while I deny all other fungi so long as they are not actually brought before me." Prof. Virchow, that is to say, will continue to deny the germ theory, however great the probabilities on its side, however numerous the cases of which it renders a just account, until it has ceased to be a theory at all, and has become a congeries of sensible facts. Had he said, "As long as a single fungus of disease remains to be discovered, it is your bounden duty to search for it," I should cordially agree with him. But by his unreserved denial he quenches the light of probability which ought to guide the practice of the medical man. Both here and in relation to the theory of evolution excess on the one side has begotten excess on the other.

In publishing the volume of "Fragments," to which the foregoing article is introductory, I could not entirely ignore the criticisms which one or two among them have evoked. Of such strictures, however, my knowledge is incomplete, their authorship causing me to give some of them a spacious berth. Nor as regards those with which I am acquainted have I deemed it necessary to offer direct refutations. They fall spontaneously to pieces in presence of the facts here set forth.—*Author's advance sheets.*

ASTRONOMICAL MAGNITUDES AND DISTANCES.

BY PROFESSOR H. S. CARHART.

THE magnitudes and distances considered in physical astronomy are so immense that we cannot hope to reach even a faint conception of them except by illustration and comparison. If even then, with our best effort, we fail to measure up to the magnificent dimensions of the universe, the attempt will at least enlarge our intellectual conceptions, and lead us out mentally into a broader place.

The results reached by modern astronomy, respecting the dimensions and distances of the heavenly bodies, are based on two lines, the radius (or semi-diameter) of the earth and the radius of its orbit; the former is accurately known, the latter approximately. In modern times the highest refinements of engineering skill have been applied to the measurement of base-lines, which furnish through triangulation arcs of a meridian. So thoroughly has this work been done that, in the opinion of Prof. Young, the error in the ascertained length of the earth's equatorial radius cannot exceed 200 feet. This radius forms our base-line for broader operations. The equatorial, horizontal parallax of the moon, or the angle subtended at the moon by the earth's equatorial radius, is found to have an average value of 57′ 2″. Hence by plane trigonometry the moon's mean distance is 238,885 miles, or nearly ten times the circumference of the earth. Light, with a velocity of 186,500 miles a second, travels from the earth to the moon and back again in two and a half seconds, thus producing that faint illumination of the dark portion of the new moon turned toward us. Knowing the moon's distance, the measurement of its apparent diameter in minutes of arc furnishes immediately its absolute diameter in miles.

So, then, this queen of the night, once supposed to be a kind of lantern, fed by exhalations from the ocean, is a body $\frac{1}{49}$ as large as the earth. It is our nearest celestial neighbor—in fact, a little outlying, condensed nebulosity; and if we had a weather-station on the lunar mountain Tycho, connected by telegraph with Washington, General Myer would receive the lunar weather-reports in fifteen seconds by electricity.

Aristarchus, in the third century before the Christian era, attempted to use the moon's distance to compute the greater distance of the sun; but the method failed, and astronomers were compelled to fall back on the radius of the earth as a base-line for a still grander triangulation. The parallax of Mars, at opposition, gave us the first approximation to the sun's distance; then the transit of Venus furnished a nearer estimate; latterly, Le Verrier, who found Neptune by figures, has also determined the distance of the sun by means of planetary perturbations; still a fourth method combines the retardation of the eclipses

of Jupiter's first satellite with the velocity of light, as determined by terrestrial measurement, and so measures off the millions of miles between us and the source of almost all our energy. These four methods, notably the last two, give us 92,360,000 miles as a near approximation to this long-sought distance. We have thus reduced this space by 3,000,000 miles, or about $\frac{1}{32}$ of the entire amount. Across this interval the radiant energy of the sun dashes in eight minutes thirteen seconds. Thermal electricity, which might be presumed to exist at the sun in great quantity, would traverse the distance in one hour thirty-six minutes. Sensation travels along our nerves at the slow rate of about 150 feet a second. Imagine an infant with an arm long enough to reach the sun. It would have to live 102 years to know that it had burned its hand in the solar fires. Counting three a second day and night, it would require an entire year to count the miles intervening between us and the sun; and to count the distance in feet, at the same rate, would consume 5,280 years, or nearly as much time as has elapsed since the introduction of man upon the earth, according to Biblical chronology.

The sun's distance being ascertained, its absolute diameter is determined from the apparent by the process applied to the moon. A near approximation to the sun's radius is 430,680 miles. Imagine the earth at the sun's centre: its surface would appear as far distant as does now the celestial vault, and the moon's orbit would fall nearly 200,000 miles within the surface, or little more than half-way from the centre out. A locomotive at thirty miles an hour would run from centre to surface in 1.63 years. Jules Verne got his traveler around the world in eighty days; at the same rate it would take him twenty-four years to make the circuit of the sun. Its volume is 1,334,000 times the earth's; but its mass, on account of its less density, is only 323,386 times as great. We say *only*, because the ratio of masses is so much less than that of volumes. But when we reflect that the spectroscope shows at least many terrestrial elements present in the sun, and that the sun contains enough of such substantial stuff as Mother Earth consists of to make more than 300,000 like her, we are prepared to admit that the ratio between the masses even is large enough for all practical purposes.

Vast and incomprehensible as we have found our distance from the sun to be, we have still to contemplate far greater reaches within the limits of the solar system. Jupiter holds on its silent course $5\frac{2}{10}$ as far away from the sun as the earth, and therefore receives only $\frac{1}{27}$ the intensity of solar radiant energy. Saturn is nearly twice as far distant as Jupiter; Uranus more than twice as far as Saturn; while Neptune glimmers at thirty times the earth's distance with light that has consumed eight and a quarter hours in flashing twice across this vast abyss since leaving the sun. At that distant boundary the light and heat of the sun have only $\frac{1}{900}$ the intensity that we enjoy, while its apparent diameter, observed from that position, would shrink to 64″,

or little more than the greatest apparent diameter of Venus. We modestly lay claim to this small corner of the universe, denominated the solar system, and assert our right to possession by calling it *ours.* What is the area of this plane bounded by Neptune's orbit, with which the planes of the other planetary orbits nearly coincide? What is the space swept by the radius-vector of this planetary child of Adams's and Le Verrier's calculations? Since circles are as the squares of their radii, this area is 900 times that comprised within the earth's orbit. Breaking this unit up into smaller ones, we find it contains twenty-six billions, five hundred millions of millions of square miles; or, with reference to the earth's entire surface, the ratio between it and the area of its orbit is 13,520,000. But Neptune's orbit exceeds this 900 times!

Conceive this orbit immersed in the universal ether, like an immense ring mapped out on the surface of still water. A pebble dropped at the centre of this ring would send its widening wavelets outward with a perfectly definite velocity. So a wave of light, emanating from the sun, with a length of no more than the $\frac{50}{1000}$ part of an inch, is propagated through this universal ether with such rapidity that in four hours and nine minutes it describes the entire area comprised within Neptune's path around the sun.

Across this vast interval quivers, too, in some mysterious way, that universal influence that we call gravitation. But at that outlying point, where Neptune holds on its silent course, it no longer exercises that dominant sway that characterizes it at the earth. The earth moves through 18.4 miles of its orbit every second, and is deflected from a straight line by the sun during that interval a little less than $\frac{12}{100}$ *of an inch* (0.11598 inch). Neptune travels 3.35 miles a second, and is deflected from a straight line during the same time only about $\frac{13}{100000}$ of an inch (0.000129 inch); yet by that slight pull the sun asserts its mastery, and brings Neptune round once in 164 years.

Vast as is this field of solar operations, we demand a still broader sphere for the exercise of our intellectual faculties. The successive eminences on which Astronomy has planted her appliances for more advanced operations stand related to each other as the terms, not of an arithmetical, but of a geometrical progression. Having settled the relative distances of this rather unsocial family of planets, the next advance is on to the stars. From the measurement of a base-line a few miles in extent, the astronomer essays, with undaunted hardihood, to fathom by triangulation the depths of space. The dog bays at the moon, the child stretches out its tiny hand to pluck the stars from the sky, and the astronomer applies his measuring-rod along the vibrating lines of light so far into immensity that blazing suns, exceeding in brightness the mid-day splendor of our own, dwindle to the luminous points of twinkling stars.

When Copernicus, the Polish astronomer, sought to extricate astronomy from the hopeless complexity into which it had become en-

tangled by cycles, epicycles, and eccentric positions, and proclaimed the heliocentric system, his opponents objected that the earth's axis, produced to the celestial sphere, with its successive positions day after day parallel to each other, should be seen to describe a circle in the heavens as the earth sweeps round through its orbit of nearly 600,000,000 miles in length. Copernicus replied that it does describe such a circle; but the stars, by reference to which it can alone be mapped out, are so distant that the circle of almost 100,000,000 miles' radius there dwindles to a point and vanishes by perspective. To reverse the line of sight, let us suppose ourselves transported to the pole-star and looking back upon the orbit of the earth. So vast is the distance that this elliptical orbit contracts almost to the infinitesimal dimensions of a point; for, at that distant station, the earth's orbital diameter subtends an angle of only 0.182″, or twice the angle called the parallax of the star. Such is the distance that the astronomer has successfully attempted to measure, starting with a primary triangle based on a determined line of only a few miles in length.

The nearest fixed star is *Alpha Centauri*, with a parallax of 0.928″, corresponding to a distance of 20,518,000 millions of miles. Light, traveling at the rate of 186,500 miles a second, requires 3.5 years to reach us from this nearest star. So the solar system, with its immense distances, is yet alone in the universe of stars; and our central luminary is separated so far from other suns that the distance to its outmost planet is almost a vanishing quantity in comparison with the distance to its nearest starry neighbors. We gaze upon the glittering heavens at night, and wrap in thought a canopy of shining stars about our earth as if it were an ornamented mantle; but could we take our station on a silent planet circling round some other starry sun, our sun would take its place as only one among the mazes of the stars.

How brilliantly Sirius shines with pure white light in the evening sky! Yet the earth has circled *seventeen times* round the sun since the light that the eye gathers to an image of the Dog-star left that glorious orb. Patiently the astronomer centres that little circle around which the pole-star sheds its guiding light, that he may adjust his instrument to parallelism with the axis of a revolving world. But since that light left its source at the pole-star, a child has grown through youth to manhood, and in his hair the gray of silver lines has begun to develop under the cares of six-and-thirty years. And these are only our nearest neighbors among the stars!

For every star visible to the naked eye under the most favorable circumstances the great Washington telescope shows from 5,000 to 8,000 more. According to the best authorities, the first six magnitudes contain 5,904 stars. Only half of these can be seen above the horizon at once; and the sixth magnitude comprises 4,424. These can be seen distinctly only on very favorable nights; so that for ordinary observation only 740 stars are visible at any moment above the horizon. There are

only twenty stars of the first magnitude, that is, of the first degree of brightness. It is demonstrable that Sirius is a hundred and sixty times as bright intrinsically as our sun. From a comparison of Sirius with the moon, and the moon with the sun, it is found that sunlight is 6,000 million times brighter than that of Sirius. But since Sirius is 1,000,000 times more distant than our sun, if brought as near us, the intensity of its light would be increased in the ratio of the square of 1,000,000 or 1,000,000 millions. This quantity, divided by 6,000 millions, would show Sirius to be at least a hundred and sixty times as bright intrinsically as our sun.

It is fair, however, to suppose that the chief cause of difference of brightness of stars is difference of distance. If so, we then have the means of approximating to the distance of even telescopic stars. Herschel estimated that stars of the first order emit, on an average, light one hundred times as intense as those of the sixth; hence the latter must be at ten times the distance, the intensity of light varying inversely as the square of the distance. Sirius is 98,000,000 of millions of miles from us; stars of the sixth magnitude are therefore about 1,000 millions of millions distant, and their light reaches us only after a flight of 169 or 170 years.

The space-penetrating power of a telescope depends upon the ratio between its aperture and the pupil of the eye. Herschel estimated that his four-foot reflector penetrated 194 times as far as the naked eye; and, as the faintest stars visible to the naked eye are ten times as distant as the brightest, it follows that the faintest stars visible in the field of Herschel's telescope are 1,940 times as distant as Sirius or *Alpha Lyræ*. In other words, Sirius would still be visible if removed to about 2,000 times its present distance. With Lord Rosse's six-foot reflector Sirius would still be visible at 3,000 times its present distance. If, therefore, this brightest star in the heavens should suddenly shoot away from us with the velocity of light, it would remain visible to the naked eye twice 170 years, since 170 years would be consumed in its flight and 170 more in the return of the light; and with Lord Rosse's telescope it could be traced 100,000 years longer (twice 3,000 times 170 years). This is the lowest estimate, too, for Sirius is many times brighter than the average star of the first magnitude. If intrinsically only four times as bright, it could still be seen by the telescope so infinitely far into space that light from it could reach us only after the lapse of 100,000 years.

But we need not pause even at these distant telescopic suns. Beyond the stars that merely dot with points of light the telescopic field of view, hovering on the outskirts of this inconceivable space swept by the far-fathoming line of telescopic vision, are discerned faintly-defined masses too distant to be resolved into stars, whose hazy light is gathered from congeries of suns, the individual blazing brightness of which is reduced in our view to the fleecy films of unresolvable nebulæ. Even

imagination tires in winging its way to these star-clusters, so far removed from us that each one may be called another universe of God. From them nothing comes to us but the faint, palpitating throb of an ethereal wave; no tidings cross that gulf save what flew throughout the universe when He who made these systems first said, "Let there be *light*." And, if thought falters and figures fail in the presence of these infinitudes of distance, no less do they when the dimensions of these nebulous fields are contemplated. The nearest star, viewed with a power of 6,000 diameters, shows no proper disk, and is still only a brilliant point. Its diameter, though perhaps greater than that of our own sun, is still at least 6,000 times too small to come within the limits of unaided vision. But many nebulæ, though almost infinitely farther removed, are still of extent sufficient to more than fill the telescopic field. Who, then, can estimate their absolute dimensions?

Such, then, are the magnitudes and distances which the godlike human intellect has undertaken to determine. And still art vies with science to fashion lenses that shall gather at their focus still more and more of that luminous intelligence that discloses to the mind of man the secrets of the outside universe. But as the space-penetrating power of the telescope is increased, and the bright spots of light are resolved into groups of brilliant stars, more nebulous haze comes up from the deep distance, indicating that the visual ray is not yet long enough to fathom the mighty depths. There is still haze behind, independent of those nebulæ shown to be gaseous by the spectroscope. The telescopic ray has not yet shot entirely through the mighty distance, leaving only the deep, dark heavens beyond as the background of the brilliant picture. The words uttered by David spring to our lips with fuller meaning when we look out upon the glorious heavens illumined by the concentrated light of these latter days: "When I consider thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained; what is man, that thou art mindful of him? or the son of man, that thou visitest him?"

HERBERT SPENCER BEFORE THE ENGLISH COPYRIGHT COMMISSION.[1]

QUESTION (*Chairman*). I need hardly ask, you are a writer of philosophical and scientific books?

Answer. I am.

Q. Would you give the commission your experience of the terms on which you published your first book?

[1] Tuesday, March 6, 1877: Lord John Manners, M. P., in the chair. Members of the commission present, Sir Henry T. Holland, Sir Louis Mallet, Sir Julius Benedict, Farrer Herschell, Dr. William Smith, J. A. Froude, Esq., Anthony Trollope, Esq., F. R. Daldy, Esq.

A. I published my first work, "Social Statics," at the end of 1850. Being a philosophical book, it was not possible to obtain a publisher who would undertake any responsibility, and I published it at my own cost. A publisher looks askance at philosophy, and especially the philosophy of a new man; hence I published on commission.

Q. Would you like to state what the result was?

A. The edition was 750; it took fourteen years to sell.

Q. Then with respect to your next work?

A. In 1855 I published the "Principles of Psychology;" I again tried in vain to get a publisher, and published again at my own cost. There were 750 copies, and the sale was very slow. I gave away a considerable number; the remainder, I suppose about 650, sold in twelve and a half years.

Q. Have you had any other similar cases?

A. Yes; I afterward, in 1857, published a series of Essays, and, warned by past results, I printed only 500. That took ten and a half years to sell. After that a second series of Essays and a little work on Education, which both had kindred results, but were not quite so long in selling. I should add that all these sales would have taken still longer but for the effect produced upon them by books published at a later period, which helped the earlier ones to sell.

Q. Have all these subsequent works to which you now refer been published in the same way?

A. No. Toward 1860 I began to be anxious to publish a "System of Philosophy," which I had been elaborating for a good many years. I found myself in the position of losing by all my books; and, after considering various plans, I decided upon the plan of issuing to subscribers in quarterly parts, and to the public in volumes when completed. Before the initial volume, "First Principles," was finished, I found myself still losing. During the issue of the second volume, the "Principles of Biology," I was still losing. In the middle of the third volume I was still losing so much, that I found I was frittering away all I possessed. I went back upon my accounts, and found that in the course of fifteen years I had lost nearly £1,200—adding interest, more than £1,200; and as I was evidently going on ruining myself, I issued to the subscribers a notice of cessation.

Q. Was that loss the difference between the money that you had actually spent in publishing the books and the money you had received in return?

A. Not exactly. The difference was between my total expenditure in publishing the books and living in the most economical way possible, and the total returns. That is to say, cutting down my expenses to the smallest amount, I lost £1,200 by the inadequate returns, and trenched to that extent upon capital.

Q. But you continued afterward, did you not, to publish?

A. I continued afterward, simply, I may say, by accident. On two

previous occasions, in the course of those fifteen years, I had been enabled to persevere, spite of losses, by bequests. On this third occasion, after the issue of the notice, property which I inherit came to me in time to prevent the cessation.

Q. May I ask how long it took before you began to be repaid for your losses?

A. My losses did not continue very long after that: the tide turned, and my books began to pay. I have calculated what length of time it has taken to repay my losses, and find they were repaid in 1874; that is to say, in twenty-four years after I began I retrieved my position.

Q. Then the commission understand that your books are now remunerative?

A. They are now remunerative, and for this reason: As I have explained, I had to publish on commission. Commission is a system which, throwing all the cost upon the author, is very disastrous for him if his books do not pay, and, as you see in this case, has been very disastrous to me; but when they do pay it is extremely advantageous, inasmuch as in that case the publisher who does the business takes only ten per cent., and the whole of the difference between cost and proceeds, minus that ten per cent., comes to the author. I have calculated what are my actual returns, on two suppositions. I have ascertained the percentage I get upon 1,000 copies, supposing that I set up the type solely for that 1,000 copies—supposing, that is, that the cost of composition comes into the cost. In that case I reap $30\frac{3}{4}$ per cent. But I reap much more. I was sanguine enough, when I began this series of books, to stereotype. The result is, that now I simply have to print additional thousands as they are demanded. If I suppose the cost of composition and stereotyping to have been paid for in the first edition, and only estimate the cost of paper and printing in the successive editions, then I am reaping $41\frac{3}{4}$ per cent. The actual percentage, of course, is one which lies between those two; but year by year, with each additional thousand, I approach more nearly to the limit of $41\frac{3}{4}$ per cent. I should point out that the result of this is that I receive, as may be supposed, a considerable return upon the moderate numbers sold.

Q. And that being so, can you tell the commission what in your opinion would have happened had there been in existence a system under which three years, say, after date of publication any one could have reprinted your books, paying you a royalty of ten per cent.?

A. The result would have been that my losses would not have been repaid now. After twenty-six years' work I should still have been out of pocket; and should be out of pocket for many years to come.

Q. (*Mr. Trollope*). Under such a system do you think that you would ever have recovered that money?

A. I am taking it on the most favorable supposition, merely supposing that all other things but percentage had remained the same.

Q. (*Chairman*). Assuming the system of royalty to be in existence,

what would be the result on your present returns, supposing losses to have been repaid?

A. Between two-thirds and three-fourths of those returns would be cut off. They would be reduced to little more than a fourth of their present amount.

Q. (*Sir H. Holland*). How do you arrive at that result?

A. By comparing the supposed percentage with the percentage I actually received.

Q. Assuming a royalty of ten per cent. upon the retail price?

A. Yes.

Q. (*Chairman*). Would it not be probable that the reduction in price of your books would so increase the sales that you would reap a larger return than you have supposed in the estimate that you have now given?

A. I think not, or very little. First of all, for the reason that the amount of reduction would not be anything like so great as at first sight appears. If a publisher issued rival editions of my books without my assent, on paying a royalty, he would only do so to make a profit beyond that which mere commission would bring. My present publisher is content with ten per cent. commission. A publisher who competed as a speculation would want to make his profit beyond the ten per cent. commission; as I ascertain, probably, at least a further ten per cent. Then there would be my own ten per cent. royalty. So that I find the reduction in price under such a royalty system would only be about fifteen per cent. That is to say, the reduction would be from 20*s.* to 17*s.* Now I am of opinion that a reduction of the price of one of my books by that amount would have but a small effect upon the sales, the market being so limited. Let me use an illustration: Take such a commodity as cod-liver oil, which is a very necessary thing for a certain limited class. Suppose it is contended that, out of regard for those to whom it is so necessary, retailers should be compelled to take a smaller profit, and you reduce the price by fifteen per cent. The consumption would be very little influenced, because there would be none except those who had it prescribed for them who would be willing to take it, and they must have it. Now take one of my books, say the "Principles of Psychology." Instead of calling it "*caviare* to the general," let us call it cod-liver oil to the general; I think it probable that if you were to ask ninety-nine people out of a hundred whether they would daily take a spoonful of cod-liver oil or read a chapter of that book, they would prefer the cod-liver oil. And if so it is quite clear, I think, that no lowering of the price by 3*s.* out of 20*s.* would in any considerable degree increase the number of persons who bought the "Principles of Psychology." The class is so limited and so special that there would be no increase of profit of a considerable kind in consequence of an increased number sold.

Q. (*Mr. Trollope*). But are there not many people who would have

benefited by cod-liver oil who cannot get it at present because of the price?

A. I think in all those cases in which they would be benefited they get it by hook or by crook when it is prescribed for them.

Q. And in the same way with your books, you think?

A. Yes. For instance, university men have to read them, and they would buy them in any case.

Q. (*Chairman*). What would have happened to you originally had there been a law giving a copyright only of short duration, under such an arrangement of percentage as that which you have just named?

A. I think it is tolerably obvious, from what I have already said, that I should not have been wholly deterred. I should have gone on losing for many years; but I think it is also clear that I should have stopped short much sooner than I did. Every author is naturally sanguine about his books; he has hopes which nobody else entertains. The result is that he will persevere, in the hope of at some time or other reaping some return, when to other persons there seems to be no probability of the kind. But supposing it becomes manifest to him that the copyright law is such that when his books succeed, if they ever do succeed, he will not get large profits, then the discouragement will be much greater, and he will stop much sooner. If I, for instance, instead of seeing that under the system of commission I should eventually, if I succeeded, repay myself and get a good return, had seen that eventually, if I succeeded, I should receive but small gains, I should have given it up.

Q. Are there other publications which you have undertaken besides those to which you have already referred?

A. Yes. About ten years ago I commenced preparing works now published under the name of "Descriptive Sociology," in large folio parts, and containing tables and classified extracts representing the civilizations of various societies. I employed gentlemen to make these compilations.

Q. Do you wish to state what has been the result of that undertaking so far?

A. Yes. I made up my accounts last Christmas. I had then in the course of those ten years expended £2,958 odd upon eight parts (five published and three in hand), and my net return from sales of the five parts published in England and America was £608 10*s.*

Q. May I ask whether you ever expect to get back the money that you have expended?

A. I may possibly get back the printing expenses on the earliest part, and most popular part, that dealing with the English civilization, in 1880, at the present rate of sale. The printing expenses of the other parts I do not expect to get back for many years longer. The cost of compilation I expect to get back if I live to be over a hundred.

Q. (*Mr. Daldy*). You spoke of the circulation in England and America. May I ask, do you send stereotype-plates to America?

A. I did at first send stereotype-plates to America, but, the thing having proved to be so great a loss, I now send a portion of the printed edition.

Q. (*Chairman*). May I ask why do you expect repayment of the cost of compilation to be so slow as you stated in your answer to my last question?

A. The reason is, that I made a promise to the compilers entailing that. The compilers are university men, to whom I could afford to give only such salaries as sufficed for their necessary expenses. To make the thing better for them, and to be some incentive, I told them that, when the printing expenses on any one part were repaid, I would commence to divide with the compiler of it the returns on subsequent sales; the result being that the cost of compilation comes back to me only at half the previous rate. I name this because it shows that, in the absence of a long copyright, I could have given no such contingent advantage to the compilers. I wish to point out another way in which a short copyright would have impeded me. As a further incentive to these compilers to do their work well, as also to make the prospect better for them, I gave them to understand that the copyrights and the stereotype-plates would be theirs after my death. Of course, with a short copyright I could not have done that.

Q. Then in your opinion it is only by a long duration of copyright that you can be enabled to recover any considerable part of the money that you have sunk in these publications?

A. Certainly. If it were possible for any one to reprint, such small return as goes toward diminishing this immense loss would be in part intercepted.

Q. But if this work, which you call "Descriptive Sociology," is so unremunerative, how do you imagine you would be in danger of having it reprinted under the suggested system of royalty?

A. It appears at first sight not a rational expectation, but it is perfectly possible. Each number of the work consists of a set of tables and a set of classified extracts. It was suggested by a reviewer of the first part, the English part, that the tables should be separately printed, mounted on boards, and hung up in schools. The suggestion was a good one, and I have even had thoughts of doing it myself. A publisher might take up that suggestion, and might issue those independently of me, and diminish what small sale I now have. Again, the work is very cumbrous and awkward; that can hardly be helped; but a publisher might see that the extracts arranged in ordinary volume form would be valuable by themselves apart from the tables, and might get a good sale independently; and again my small returns would be cut into.

Q. (*Sir H. Holland*). That objection of yours would be partly met

by the suggestion of Mr. Macfie, who brought this question of royalty before us, because his suggestion is, that no reprint is to differ from the original edition without the author's consent, either in the way of abbreviation, enlargement, or alteration of the text. Therefore, under that regulation, if that is carried out, a publisher could not print half of this book without your consent?

A. That would so far, if it can be practically worked out, meet my objection.

Q. (*Mr. Trollope*). But you have stated that you thought yourself of using this form of abridgment to which allusion is made?

A. I have.

Q. And if this form of abridgment when made by you could be republished again by anybody else, then your profit would be interfered with?

A. No doubt of it.

Q. (*Chairman*). Supposing the suggested system of short copyright and royalty had been in force, would you have undertaken these works to which you have referred?

A. Certainly not. The enterprise was an unpromising one, pecuniarily considered, and it would have been almost an insane one, I think, had there not been the possibility of eventually getting back some returns from sales that were necessarily very slow. Moreover, the hopes under which the compilers have worked I could never have given to them.

Q. Then are we to gather from your evidence that the system of short copyright and royalty would be injurious to the books of the graver class which do not appeal to the popular tastes?

A. I think so; it would be especially injurious to that particular class which of all others needs encouragement.

Q. (*Sir H. Holland*). As requiring most thought and brain-work on the part of the author?

A. Yes, and being least remunerative.

Q. (*Chairman*). I understand you to say that in all these cases you have not parted with the copyright yourself?

A. No, I have not.

Q. Now, assuming that the authors of these graver books sold their copyrights, do you think that this royalty system would still act prejudicially upon them?

A. I think very decidedly. I have understood that it is contended that authors who sell their copyrights would not be affected by this arrangement. One of the answers I heard given here to-day sufficed to show that that is not true; inasmuch as a publisher who had to meet these risks would not give as much for copyright as he would otherwise give. His argument would be unanswerable. He would say: "Your book is a success, or not a success; if not a success, I lose what I give you for copyright; if a success, I shall have it reprinted upon

me, and again I shall lose what I give you for copyright. I must, therefore, reduce the amount which I give for the copyright." Moreover, I believe that the reduction in the value of copyrights would be much greater than the facts justified. In the first place, the publisher himself would look to the possibility of reprinting with a fear beyond that which actual experience warranted. Frequently a suggested small danger acts upon the mind in a degree out of all proportion to its amount. Take such a case as the present small-pox epidemic, in which you find one person in 30,000 dies in a week; in which, therefore, the risk of death is extremely small. Look at this actual risk of death and compare it with the alarms that you find prevailing among people. It is clear that the fear of an imagined consequence of that kind is often much in excess of the actual danger. Similarly, I conceive that the publisher himself would unconsciously over-estimate the danger of reprints. But beyond that he would exaggerate his over-estimate as an excuse for beating down copyright. He would say to the author: "You see this danger; I cannot face so great a risk without guarding myself; and you must submit to a large reduction."

(Mr. Spencer was subsequently called before the committee again, and we shall give his interesting evidence next month.)

THE BEGINNING OF NERVES IN THE ANIMAL KINGDOM.

By GEORGE J. ROMANES.

NERVE-TISSUE universally consists of two elementary structures, viz., very minute nerve-cells and very minute nerve-fibres. The fibres proceed to and from the cells, so in some cases serving to unite the cells with one another, and in other cases with distant parts of the animal body. Nerve-cells are usually found collected together in aggregates, which are called nerve-centres or ganglia, to and from which large bundles of nerve-fibres come and go.

To explain the *function* of nerve-tissue, it is necessary to begin by explaining what physiologists mean by the term "excitability." Suppose that a muscle has been cut from the body of a freshly-killed animal; so long as it is not interfered with in any way, so long will it remain quite passive. But every time a stimulus is supplied to it, either by means of a pinch, a burn, an electrical shock, or a chemical irritant, the muscle will give a single contraction in response to every stimulation. And it is this readiness of organic tissues to respond to a suitable stimulus that physiologists designate by the term "excitability."

Nerves, no less than muscles, present the property of being excitable. If, together with the excised muscle, there had been removed from the animal's body an attached nerve, every time any part of this nerve is stimulated the attached muscle will contract as before. But it must be carefully observed that there is this great difference between these two cases of response on the part of the muscle—that, while in the former case the muscle responded to a stimulus *applied directly to its own substance*, in the latter case the muscle responded to a stimulus applied *at a distance from its own substance*, which stimulus was then *conducted* to the muscle by the nerve. And in this we perceive the characteristic function of nerve-*fibres*, viz., that of conducting stimuli to a distance. The function of nerve-*cells* is different, viz., that of accumulating nervous energy; and, at fitting times, of discharging this energy into the attached nerve-fibres. The nervous energy, when thus discharged, acts as a stimulus to the nerve-fibre; so that, if a muscle is attached to the end of a fibre, it contracts on receiving this stimulus. I may add that, when nerve-cells are collected into ganglia, they often appear to discharge their energy spontaneously; so that in all but the very lowest animals, whenever we see apparently *spontaneous* action, we infer that ganglia are probably present. Lastly, another important distinction must be borne in mind—the distinction, namely, which I now draw between muscle and nerve. A stimulus applied to a nerveless muscle can only course through the muscle by giving rise to a visible wave of contraction, which spreads in all directions from the seat of disturbance as from a centre. A nerve, on the other hand, conducts the stimulus without undergoing any change of shape. Now, in order not to forget this distinction, I shall always speak of muscle-fibres as conveying a *visible* wave of *contraction*, and of nerve-fibres as conveying an *invisible*, or *molecular*, wave of *stimulation*. Nerve-fibres, then, are functionally distinguished from muscle-fibres—and also from protoplasm—by displaying the property of conducting invisible, or molecular, waves of stimulation from one part of an organism to another, so establishing physiological continuity between such parts, *without the necessary passage of contractile waves.*

Such being the structure and the function of nerve-tissue in its fully evolved form, I will now proceed to give the results of my researches on the structure and function of nerve-tissue where this tissue is first found to occur in the ascending series of animal life. The animals in which it so occurs are the *Medusæ* or jelly-fishes, which must be familiar to all who frequent the seaside. These animals present the general form of a mushroom. The organ which occupies the same position as the stalk does in the mushroom is the mouth and stomach of the medusa, and is called the polypite; while the organ which resembles in shape the dome of the mushroom consitutes the main bulk of the animal, and is called the swimming-bell. Both the polypite and the swimming-bell are almost entirely composed of a thick, transparent, and non-

contractile jelly; but the whole surface of the polypite, and the whole *concave* surface of the bell, are overlaid by a thin layer, or sheet, of contractile tissue. This tissue constitutes the earliest appearance in the animal kingdom of true muscular fibres. The thickness of this continuous layer of incipient muscle is pretty uniform, and is nowhere greater than that of very thin paper. The margin of the bell supports a series of highly contractile tentacles, and also another series of bodies which are of great importance in the following researches. These are the so-called marginal bodies, which are here represented, but the structure of which I need not describe. Lastly, it may not be superfluous to add that all the *Medusæ* are locomotive. The mechanism of their locomotion is very simple, consisting merely of an alternate contraction and relaxation of the entire muscular sheet which lines the cavity of the bell. At each contraction of this muscular sheet the gelatinous walls of the bell are drawn together; the capacity of the bell being thus diminished, water is ejected from the open mouth of the bell backward, and the consequent reaction propels the animal forward. In these swimming movements systole and diastole follow one another with as perfect a rhythm as they do in the beating of a heart.

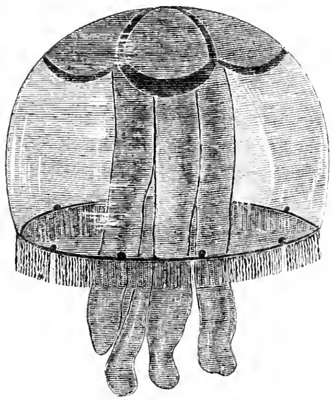


Fig. 1.

Previous to my researches, the question as to whether or not the *Medusæ* possess a nervous system was one of the most vexed questions in biology—some eminent naturalists maintaining that they could detect microscopical indications of nervous tissues, and others maintaining that these indications were delusive—the deliquescent nature of the gelatinous tissues rendering microscopical observation in their case a matter of great difficulty. But amid all this controversy no one appears to have thought of testing the question by means of physiological experiments as distinguished from microscopical observations. Accordingly, I made the experiment of cutting off now one part and now another part of a jelly-fish, in order to see whether by so doing I could alter the character of its movements in such a way as to show that I had removed nerve-centres or ganglia. The results which I obtained were in the highest degree astonishing. For, on removing the extreme margin of the swimming-bell, I invariably found that the operation caused immediate, total, and permanent paralysis of the entire organ. That is to say, if, with a pair of scissors, I cut off the whole marginal rim of the bell, carrying the cut round just above the insertion of the tentacles, the moment the last atom of the margin was removed, the

pulsations of the bell instantly and forever ceased. On the other hand, the severed margin continued its pulsations with vigor and pertinacity, notwithstanding its severance from the main organism. For hours and even for days after its removal the severed margin would continue its rhythmical contractions; so that the contrast between the death-like quiescence of the mutilated bell and the active movements of the thread-like portion which had just been removed from its margin was a contrast as striking as it is possible to conceive.

I may here add that, although excision of the margin of the bell thus completely destroys the *spontaneity* of the bell, it does not at all diminish the *excitability* of the bell; so that, although the mushroom-shaped mass will never move of its own accord after having been thus mutilated, it will give any number of locomotor contractions in response to an equal number of artificial stimulations, just in the same way as a frog with its head (nerve-centres of spontaneity) removed will give any number of hops in response to successive stimulations.

These experiments, therefore, prove conclusively that, in the extreme marginal rim of all the numerous species of *Medusæ* which I examined, there is situated an intensely localized system of nervous centres, to the functional activity of which the rhythmical contractions of the swimming-bell are exclusively due. And as the *Medusæ* are thus the lowest animals in which a nervous system has yet been or probably ever will be discovered, we have in them the animals upon which we may experiment with the best hope of being able to elucidate all questions concerning the origin and endowments of primitive nervous tissues. I may here add that these experiments were independently made by Dr. Eimer, of Würzburg.

After I had made the observation which I have described, it seemed to me desirable to follow it up with a number of other physiological, as distinguished from histological, researches. For I was much struck by the certainty and precision of the results which I had obtained by experiment, as distinguished from the uncertainty and disagreement of the results which had previously been obtained by the histological methods. Accordingly, I decided, in the first instance, to feel my way in the direction of physiological experiment before beginning that systematic histological research which, sooner or later, it was manifestly imperative to make. Study of function having so far guided the study of structure as to show that it was in the margin of the *Medusæ* that we must look for the principal if not the exclusive supply of central nervous tissue, it seemed desirable to ascertain how much light a further study of function might throw on the character and the distribution of the peripheral nervous tissue.[1] Accordingly, I began my physiological work chiefly with the view of guiding my subsequent histo-

[1] Although it sounds somewhat paradoxical to speak of the central nervous tissue as distributed on the periphery of a circular animal, and of the peripheral nervous tissue as occupying all the more centrally situated parts, the paradox is unavoidable.

logical work. But, as the physiology of the subject continued to open up in the wonderful way in which it did, I felt it was undesirable either, on the one hand, to suspend this part of the inquiry, or, on the other hand, any longer to defer a thorough investigation of the histological part. I therefore represented the case to my friend Mr. Schäfer, who very kindly consented to join me in Scotland, with the view of coöperating with me in the research. The histological results which he has obtained from a most skillful and painstaking investigation are in the highest degree interesting. He worked chiefly with *Aurelia aurita*, and found that the tissue which performs the ganglionic function in the marginal bodies is of the nature of modified epithelium-cells, the ganglionic function of which could scarcely have been suspected but for the paralyzing effects which are produced by their excision. From these marginal ganglia there radiate what he regards as delicate pale nerve-fibres, which sometimes present the appearance of fibrillation. These fibres spread over the entire expanse of the muscular sheet in great numbers. It will thus be seen that these microscopical researches of Mr. Schäfer fully bear out my inference from the result of physiological experiments, which was previously published at the Royal Society—the inference, namely, that the entire muscular sheet of the *Medusæ* is overspread by a dense plexus of nervous channels. But these researches of Mr. Schäfer tend to negative another inference which was published at the Royal Institution—the inference, namely, as to the degree in which these channels are *differentiated*.[1] As the facts on which this inference was based have not been previously published in the *Fortnightly Review*, and as, apart from the dubious inference, they are facts of the first importance, it is necessary that I should here very briefly restate them. The annexed woodcut (Fig. 2) represents a specimen of *Aurelia aurita* with its polypite cut off at the base, and the under or concave surface of the bell exposed to view. The bell, when fully expanded, as here represented, is about the size of a soup-plate, and in it all

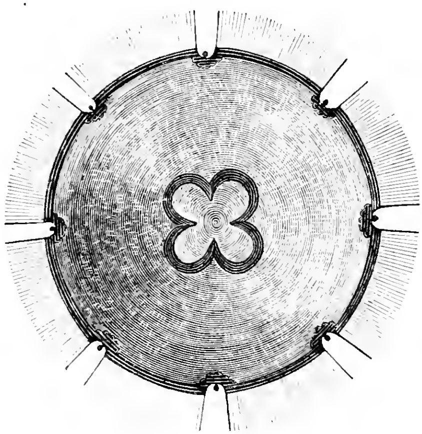


FIG. 2.

[1] I may here state that, previous to Mr. Schäfer's researches, I had observed both the tissue-elements which he describes; but I hesitated to pronounce upon their nervous character. It will thus be understood that even now, without wishing to dispute the accuracy of his judgment in this matter, I do wish it to be known that the responsibility of this judgment rests entirely with my friend.

the ganglia are collected into these eight marginal bodies, as proved by the fact that on cutting out all the eight marginal bodies paralysis of the bell ensues. Therefore, if the reader will imagine this diagram to be overspread with a disk of muslin, the fibres of which start from one or other of these marginal ganglia, he will gain a tolerably correct idea of the lowest nervous system in the animal kingdom. Now suppose that seven of these eight ganglia are cut out, the remaining one then continues to supply its rhythmical discharges to the muscular sheet of the bell, the result being, at each discharge, two contractile waves, which start at the same instant, one on each side of the ganglion, and which then course with equal rapidity in opposite directions, and so meet at the point of the disk which is opposite to the ganglion. Suppose now a number of radial cuts are made in the disk, according to such a plan as this, wherein every radial cut deeply overlaps those on either side of it. The contractile waves which now originate from the ganglion must either become blocked and cease to pass round the disk, or they must zigzag round and round the tops of these overlapping cuts. Now, remembering that the passage of these contractile waves is presumably dependent on the nervous network progressively distributing the ganglionic impulse to the muscular fibres, surely we should expect that two or three overlapping cuts, by completely severing all the nerve-fibres lying between them, ought to destroy the functional continuity of these fibres, and so to block the passage of the contractile wave. Yet this is not the case; for, even in a specimen of *Aurelia* so severely cut as the one here represented, the contractile waves, starting from the ganglion, continued to zigzag round and round the entire series of sections.

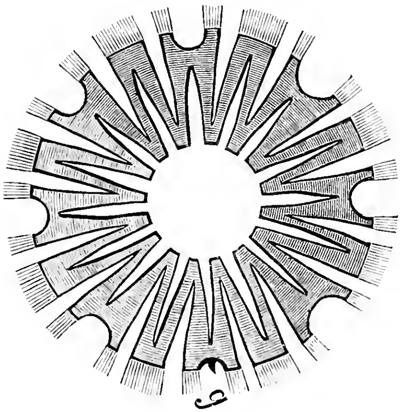


Fig. 3.

The same result attends other forms of section. Here, for instance, seven of the marginal ganglia having been removed as before, the eighth one was made the point of origin of a circumferential section, which was then carried round and round the bell in the form of a continuous spiral—the result, of course, being this long ribbon-shaped strip of tissue with the ganglion at one end, and the remainder of the swimming-bell at the other. Well, as before, the contractile waves always originated at the ganglion; but now they had to course all the way along the strip until they arrived at its other extremity; and, as each wave arrived at that extremity, it delivered its influence into the remainder of the swimming-bell, which thereupon contracted.

Now, in this experiment, when the spiral strip is only made about half an inch broad, it may be made more than a yard long before all the bell is used up in making the strip; and as nothing can well be imagined as more destructive of the continuity of a nerve-plexus than this spiral mode of section must be, we cannot but regard it as a very remarkable fact that the nerve-plexus should still continue to discharge its functions. Indeed, so remarkable does this fact appear, that to avoid accepting it

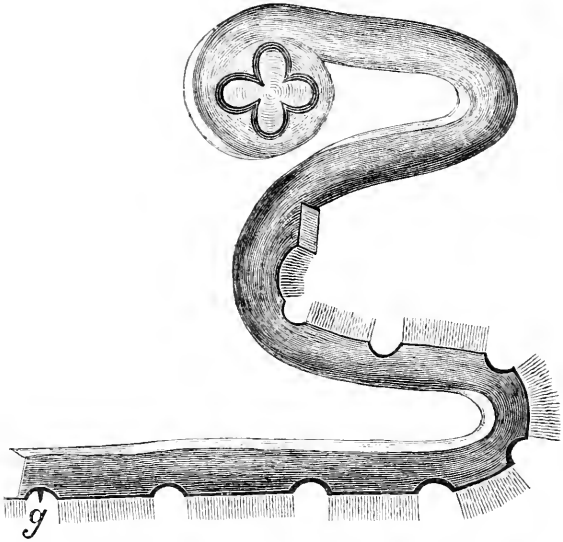


FIG. 4.

we may well feel inclined to resort to another hypothesis—namely, that these contractile waves do not depend for their passage on the nervous network at all, but that they are of the nature of muscle-waves, or of the waves which we see in indifferentiated protoplasm, where all parts of the mass being equally excitable and equally contractile, however severely we cut the mass, so long as we do not actually divide it, contractile waves will pass throughout the whole mass. But this very reasonable hypothesis of the contractile waves in the *Medusæ* being possibly nothing other than muscle-waves, is negatived by another fact of a most extraordinary nature. At the beginning of this article I stated that the distinguishing function of nerve consists in its power of conducting stimuli to a distance, irrespective of the passage of a contractile wave; and I may here add that, when a stimulus so conducted reaches a ganglion or nerve-centre, it causes the ganglion to discharge by so-called "reflex action." Now, this distinguishing function of nerve can plainly be proved to be present in the *Medusæ*. For instance, take such a section of *Aurelia* as this one (Fig. 5), wherein the bell has been cut into the form of a continuous parallelogram of tissue with the polypite and

a single remaining ganglion at one end. (The cuts interposed in the parallelogram may for the present be neglected.) Now, if the end-mark *a* of the nervo-muscular sheet most remote from the ganglion be gently brushed with a camel's-hair brush—i. e., too gently to start a responsive contractile wave—the ganglion at the other end will shortly afterward discharge, as shown by its starting a contractile wave at its own end of the parallelogram *b*, thus proving that the stimulus caused

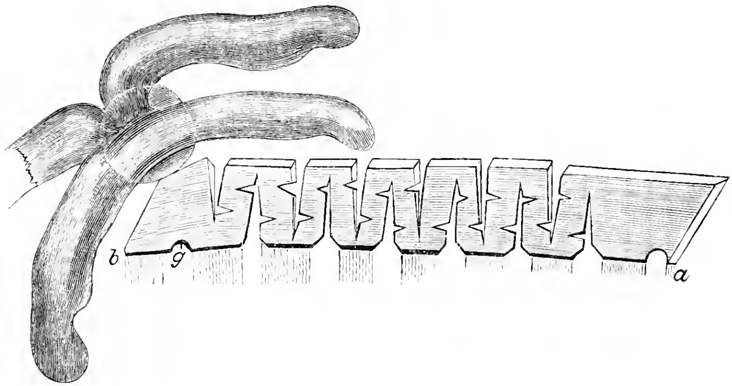


FIG. 5.

by brushing the tissue at the other end, *a*, must have been conducted all the way along the parallelogram to the terminal ganglion *b*, so causing the terminal ganglion to discharge by reflex action. Indeed, in many cases, the passage of this nervous wave of stimulation admits of being actually *seen*. For the numberless tentacles which fringe the margin of *Aurelia* are more highly excitable than is the general contractile tissue of the bell; so that, on brushing the end *a* of the parallelogram remote from the ganglion, the tentacles at this end respond to the stimulus by a contraction, then those next in the series do the same, and so on—a wave of contraction being thus set up in the tentacular fringe, the passage of which is determined by the passage of the nervous wave of stimulation in the superjacent nervous network. This tentacular wave is here represented as having traversed half the whole distance to the terminal ganglion, and when it reaches that ganglion it will cause it to discharge by reflex action, so giving rise to a visible wave of muscular contraction passing in the direction *b a*, opposite to that which the nervous or tentacular wave had previously pursued. Now, this tentacular wave, being an optical expression of the passage of a wave of stimulation, is a sight as beautiful as it is unique; and it affords a first-rate opportunity of settling this all-important question, namely—will this conductile or nervous function prove itself as tolerant toward a section of the tissue as the contractile or muscular function has already proved itself to be? For, if so, we shall

gain nothing on the side of simplicity by assuming that the contractile waves are merely muscle-waves, so long as the *undoubtedly nervous* waves are equally able to pass round sections interposed in their path. Briefly, then, I find that the nervous waves of stimulation are quite as able to pass round these interposed sections as are the waves of contraction. Thus, for instance, in this specimen (Fig. 5), the tentacular wave of stimulation continued to pass as before, even after I had submitted the parallelogram of tissue to the tremendously severe form of section which is represented in the diagram. And this fact, I am not afraid to say, is one of the most important that has ever been brought to light in the whole range of invertebrate physiology. For what does it prove? It proves that the distinguishing function of nerve, where it first appears upon the scene of life, admits of being performed vicariously to almost any extent by all parts of the same tissue-mass. If we revert to our old illustration of the muslin as representing the nerve-plexus, it is clear that, however much we choose to cut the sheet of muslin with such radial or spiral sections as are represented in the diagram, one could always trace the threads of the muslin with a needle round and round the disk, without once interrupting the continuity of the tracing; for, on coming to the end of a divided thread, one could always double back on it and choose another thread which might be running in the required direction. And this is what we are now compelled to believe takes place in the fibres of this nervous network, if we assume that these visible fibres are the only conductive elements which are present. Whenever a stimulus-wave reaches a cut, we must conclude that it doubles back and passes into the neighboring fibres, and so on, time after time, till it succeeds in passing round and round any number of overlapping cuts.

Now, it was in view of this almost unlimited power of vicarious action on the part of the fibres composing the (then) hypothetical nervous plexus, that I was in the first instance inclined to suppose these nerve-fibres to be of a non-fully differentiated character; and although the above detailed experiments, and others of a similar kind, proved that an intimate network of such channels was present, I scarcely expected that they would admit of being distinguished by the microscope. But, not to give an inference the value of a fact, I was careful to state in the publication where this inference was adduced—viz., in the printed abstract of a Royal Institution lecture—that this position was only "provisional," and that, until I should have had "time to conduct a systematic inquiry concerning the histology of the *Medusæ*," the inference in question must be regarded as premature and uncertain."[1] Such a systematic inquiry has now shown that this provisional inference was

[1] I guarded the inference in this way, lest the fibres in question should afterward prove to be nerves; and it will therefore be observed that, supposing them to be nerves, the above inference cannot be negatived until it is shown that there are no other nervous channels present of a less differentiated character.

perhaps erroneous, and that, in any case, when stained with gold, some of the nervous channels show themselves in the form of fully differentiated nerves. Now this fact, it is needless to say, greatly enhances the interest of the previous experiments. If, as I formerly said, the proof of vicarious action being possible to an almost unlimited extent in these incipient nerve-fibres appeared to me one of the most interesting among the additions to our knowledge of invertebrate physiology, much more interesting does this proof become if we further learn that these incipient nerve-fibres are only incipient in the sense of constituting the earliest appearance of nerve-fibres in the animal kingdom. For if these *true* nerve-fibres admit, from the peculiarly favorable plan of their anatomical distribution, of being proved to be not improbably capable of vicarious action to so extraordinary a degree, we may become the more prepared to believe that nerve-fibres elsewhere are similarly capable of vicarious action. But the interest does not end here, for Mr. Schäfer's numerous preparations all show the highly remarkable fact that the nerve-fibres which so thickly overspread the muscular sheet of *Aurelia* do not constitute a true plexus, but that each fibre is comparatively short, and nowhere joins with any of the other fibres. That is to say, although the constituent fibres of the network cross and recross one another in all directions—sometimes, indeed, twisting around one another like the strands of a rope—they can never be actually seen to join, but remain anatomically isolated throughout their length. So that the simile by which I have represented this nervous network—the simile, namely, of a sheet of muslin overspreading the whole of the muscular sheet—is as a simile even more accurate than has hitherto appeared; for just as in a piece of muslin the constituent threads, although frequently meeting one another, never actually coalesce, so, in the nervous network of *Aurelia*, the constituent fibres, although frequently in contact, never actually unite.

Now, if it is a remarkable fact that in a fully differentiated nervous network the constituent fibres are not improbably capable of vicarious action to almost any extent, much more remarkable does this fact become when we find that no two of these constituent nerve-fibres are histologically continuous with one another. Indeed, it seems to me that we have here a fact as startling as it is novel. There can scarcely be any doubt that *some* influence is communicated from a stimulated fibre *a* to the adjacent fibre *b* at the point where these fibres come into close apposition. But what the nature of the process may be whereby a disturbance in the excitable protoplasm of *a* sets up a sympathetic disturbance in the anatomically separate protoplasm of *b*, supposing it to be really such—this is a question concerning which it would as yet be premature to speculate.[1] But if, for the sake of a name, we call this

[1] That it can scarcely be an *electrically inductive* effect would seem to be shown by the fact that such effects can only be produced on nerves by strong currents; and also by the fact that the saline tissues of the swimming-bell must short-circuit any feeble electrical currents as soon as they are generated.

process, whatever it may be, a process of *physiological induction*, we may apply a similar name to a process which seems closely analogous to, if it is not really identical with, the process we are now considering. I refer to some highly remarkable observations which were published a year or two ago in Mr. Darwin's work on "Insectivorous Plants." It is there stated that, while looking at a linear series of excitable cells with the microscope, Mr. Darwin could observe the passage of a stimulus along the series, the protoplasm in the cells immediately stimulated first undergoing aggregation, then the protoplasm in those next adjacent doing the same, and so on. Now, the protoplasm in each cell was separated from the protoplasm in the adjacent cell by the walls of both the cells; yet, notwithstanding there was no observable anatomical continuity between these masses of protoplasm, a disturbance set up in any one of the series of masses immediately set up, by some process of physiological induction, a sympathetic disturbance in the immediately adjacent masses.

This, then, is one case that seems to be comparable with the case of physiological induction in the nerve-fibres of *Aurelia*, and I think it may be well for physiologists to keep awake to the fact that a process of this kind probably takes place in the case of these nerve-fibres. For it thus becomes a possibility which ought not to be overlooked, that in the fibres of the spinal cord, and in ganglia generally, where histologists have hitherto been unable to trace any anatomical or structural continuity between cells and fibres, which must nevertheless be supposed to possess physiological or functional continuity—it thus becomes a possibility that in these cases no such anatomical continuity exists, but that the physiological continuity is maintained by some such process of physiological induction as probably takes place among the nerve-fibres of *Aurelia*.

Before quitting the histological part of the subject, it is desirable to state that at about the same time as Mr. Schäfer's work was communicated to the Royal Society, two other papers were published in Germany on the same subject. One of these papers was by Messrs. Hertwig, and the other by Dr. Eimer. Both memoirs display a large amount of patient research, and describe the character and distribution of the nervous tissues in various species of *Medusæ*. These authors, however, do not describe the nervous network which has been described by Mr. Schäfer. I may add the interesting fact that the nervous tissues in *Medusæ* appear to be exclusively restricted to the body-layer which is called the ectoderm, and which is the structural homologue of that body-layer in which the nervous tissues of all the higher animals are known to have their origin during the life-history of the embryo.

Proceeding now to state some further results of various physiological experiments, I shall begin with the department Stimulation. And first to take the case of a physiological principle which I observed in the jelly-fish, and which has also been found to run through all ex-

citable tissues. If a single stimulation is supplied to a paralyzed jelly-fish, a short period, called the period of latency, will elapse, and then the jelly-fish will give a single weak contraction. If, as soon as the tissue has relaxed, the stimulation is again repeated, the period of latency will be somewhat shorter, and will be followed by a somewhat stronger contraction. Similarly, if the stimulation is repeated a third time, the period of latency will be still shorter, and the ensuing contraction still stronger. And so on up to nine or ten times, when the period of latency will be reduced to its *minimum*, while the force of the contraction will be raised to its *maximum*. So that in the jelly-fish the effect of a series of excitations supplied at short intervals from one another, is that of both arousing the tissue into a state of increased *activity*, and also of producing in it a state of greater *expectancy*. Now, effects very similar to these have been found to occur in the case of the excitable plants by Dr. Burdon-Sanderson; in the case of the frog's heart by Dr. Bowditch; and in the case of reflex action of the spinal cord by Dr. Sterling. Indeed, the only difference in this respect between these four tissues, so widely separated from one another in the biological scale, consists in the *time* which may be allowed to elapse between the occurrence of the successive stimuli, in order to produce this so-called summating effect of one stimulus upon its successor: the *memory*, so to speak, of the heart-tissue, for the occurrence of a former stimulus being longer than the memory of the jelly-fish tissue; while the memory of the latter is longer than that of the plant-tissue. And I may here add that even in our own organization we may often observe the action of this principle of the summation of stimuli. For instance, we can tolerate for a time the irritation caused by a crumb in our throats; but very rapidly the sense of irritation accumulates to a point at which it becomes impossible to avoid coughing. And similarly with tickling generally, the convulsive reflex movements to which it gives rise become more and more incontrollable the longer the stimulation is continued, until they reach a maximum point, where, in persons susceptible of this kind of stimulation, the muscular action passes completely beyond the power of the will. Lastly, I may further observe, what I do not think has ever been observed before, that even in the domain of psychology the action of this principle admits of being clearly traced. Who, for instance, has not felt it in the case of the ludicrous? We can endure for a short time, without giving any visible response, the psychological stimulation which is supplied by a comical spectacle; but if the latter continues sufficiently long in a sufficiently ludicrous manner, our appropriate emotion very rapidly runs up to a point at which it becomes incontrollable, and we burst into an explosion of ill-timed laughter. But in this case of psychological tickling, as in the previous case of physiological tickling, some persons are much more susceptible than others. Nevertheless, there can be no doubt that, from the excitable tissues of a plant, through those of a

jelly-fish and a frog, up even to the most complex of our psychological processes, we have in this recently discovered principle of the summation of stimuli a very remarkable uniformity of occurrence.

Hitherto light has never been actually proved to act as a direct stimulus to ganglionic matter. It is therefore of interest to note that it thus acts in the case of some species of *Medusæ*. *Sarsiæ*, for instance, almost invariably respond to a single flash by giving one or more contractions. If the animal is vigorous, the effect of a momentary flash thrown upon it during one of the natural pauses is immediately to originate a bout of swimming; but if the animal is non-vigorous, it usually gives only one contraction in response to every flash. That it is light *per se*, and not the sudden transition from darkness to light, which here acts as the stimulus, is proved by the result of the converse experiment, viz., placing a vigorous specimen in sunlight, waiting till the middle of one of the natural pauses, and then suddenly darkening. In no case did I thus obtain any response. Indeed, the effect of this converse experiment is rather that of inhibiting contractions; for if the sunlight be suddenly shut off during the occurrence of a swimming-bout, it frequently happens that the quiescent stage immediately sets in. Again, in a general way, it is observable that *Sarsiæ* are more active in the light than they are in the dark: it appears as though light acts toward these animals as a constant stimulus. Nevertheless, when the flashing method of experimentation is employed, it is observable that the stimulating effect of the flashes progressively declines with their repetition. The time during which the deleterious effect of one such stimulus on its successor lasts appears to be about a quarter of a minute. The period of latent stimulation is, judging by the eye, as short in the case of luminous as in that of other stimulation; but when the efficacy of luminous stimulation is being diminished by frequent repetition, the period of latency is very much prolonged.

The question as to what part of the organism it is which is thus susceptible of luminous stimulation, was easily determined by detaching various parts of the organism and experimenting with them separately. I thus found that it is the marginal bodies alone which are thus affected by light; for, when these are removed, the swimming-bell, though still able (in the case of *Sarsia*)[1] to contract spontaneously, no longer responds to luminous stimulation; whereas, if only one marginal body be left *in situ*, or if the severed margin, or even a single excised marginal body, be experimented on, unfailing response to this mode of stimulation may be obtained.

Responses to luminous stimulation occur in all cases equally well, whether the light employed be direct sunlight, diffused daylight, polar-

[1] In all the *naked*-eyed division of *Medusæ*, to which *Sarsia* belongs, total paralysis of the bell can only be obtained by removing the *entire margin*; but in all the covered-eyed division, to which *Aurelia* belongs, paralysis of the bell ensues on removing the *marginal bodies alone*.

ized light, or any of the luminous rays of the spectrum employed separately. On the other hand, neither the non-luminous rays beyond the red, nor those beyond the violet, appear to exert the smallest degree of stimulating effect. Hence, in all respects, the rudimentary eye of *Sarsia* appears to be affected by the same qualities of light as are our own.

Not so, however, in the case of another species of medusa, which I have called *Tiaropsis polydiademata.* This jelly-fish responds to luminous stimulation in the same peculiar manner as it responds to all other artificial—as distinguished from natural ganglionic—stimulation; that is to say, instead of giving a locomotor contraction of the bell, it throws the bell into a violent contraction of a long-sustained character, resembling cramp or tonic spasm. Now, in the case of this medusa, the luminous stimulation requires to act for a comparatively long time in order to produce a response. For, while in *Sarsia* the period of latent stimulation appears to be as short in the case of luminous as it is in the case of other modes of stimulation, in the case of *Tiaropsis* this is not so, although, as regards all modes of stimulation other than luminous, the latent period is as brief in the case of *Tiaropsis* as it is in the case of *Sarsia.* In other words, while this period is quite as instantaneous in the case of *Tiaropsis* as it is in the case of *Sarsia* when the stimulus employed is other than luminous, in response to light the characteristic spasm does not take place till slightly more than a second has elapsed after the first occurrence of the stimulus. Now, as my experiments on *Sarsia* proved that the only respect in which luminous stimulation differs from other modes of stimulation consists in its being exclusively a stimulation of ganglionic matter, we have evidence, in the case of *Tiaropsis*, of an enormous difference between the rapidity of response to stimuli by the contractile and by the ganglionic tissues respectively. The next question, therefore, is as to whether the enormous length of time occupied by the process of stimulation in the ganglia is due to any necessity on the part of the latter to accumulate the stimulating influence of light prior to originating a discharge, or to an immensely lengthened period of latent stimulation manifested by the ganglia under the influence of light.[1] To answer this question, I first allowed a continuous flood of light to fall on the medusid, and then noted the time at which the responsive spasm first began. This time, as already stated, was slightly more than one second. I next threw in single flashes of light of measured duration, and found that, unless the

[1] The period of latent stimulation merely means the time after the occurrence of an excitation during which a series of physiological processes are taking place which terminate in a contraction; so that, whether the excitation is of a strong or of a weak intensity, the period of latent stimulation is not much affected. The above question, therefore, was simply this: Does the prolonged delay on the part of these ganglia, in responding to light, represent the time during which the series of physiological processes are taking place in response to an adequate stimulus, or does it represent the time during which light requires to act before it becomes an adequate stimulus?

flash was of slightly more than one second's duration, no response was given. That is to say, the minimal duration of a flash required to produce a responsive spasm was just the same as the time during which a continuous flood of light required to operate in order to produce a similar spasm. From this, therefore, I conclude that the enormously long period of latent excitation in the case of luminous stimuli is not, properly speaking, a period of latent excitation at all; but that it represents the time during which a certain summation of stimulating influence is taking place in the ganglia, which requires somewhat more than a second to accumulate, and which then causes the ganglia to originate an abnormally powerful discharge. So that in the action of light upon the ganglionic matter of this medusid we have some analogy to its action on certain chemical compounds in this respect—that, just as in the case of those compounds which light is able to split up, a more or less lengthened exposure to its influence is necessary in order to admit of the summating influence of its vibrations on the molecules; so in the case of this ganglionic material, the decomposition which is effected in it by light, and which terminates in an explosion of nervous energy, can only be effected by a prolonged exposure of the unstable material to the summating influence of the luminous vibrations. Probably, therefore, we have here the most rudimentary type of a visual organ that is possible; for it is evident that, if the ganglionic matter were a very little more stable than it is, it would either altogether fail to be thrown down by the luminous vibrations, or would occupy so long a time in the process that the visual sense would be of no use to its possessor. How great is the contrast between the excitability of such a sense-organ and that of a fully evolved eye, which is able to effect the needful molecular changes in response to a flash as instantaneous as that of lightning!

Before leaving the case of luminous stimulation, I may observe that some of the *Medusæ* appear to be very fond of light. For, on placing a number of *Sarsiæ* in a large bell-jar in a dark room, and then throwing a beam of light through a part of the water in the bell-jar, the *Medusæ* all crowded into the path of the beam, and dashed themselves against the glass nearest to the light, very much as moths might do under the influence of similar stimulation. On moving the lamp round the jar, a cluster of *Medusæ* always followed it. This latter experiment is important, because it proves that the marginal ganglia are so far coördinated in their action that they can steer the animal in any particular direction.

Staurophora laciniata is a large species of naked-eyed medusa, which responds to stimulation in two very different ways, according as the stimulation is applied to the nervo-muscular sheet, or to the marginal ganglia. For, if the stimulation is applied to the nervo-muscular sheet, the response is an ordinary locomotor contraction; whereas, if the stimulation is applied to the marginal ganglia, the response is a

tonic spasm of the same kind as that already alluded to in the case of *Tiaropsis polydiademata*. Now, it is a remarkable fact that into whatever form the bell of this medusa is cut—say, for instance, into the form of a long ribbon—whenever a locomotor contraction is started by stimulating any part of the general nervo-muscular sheet, it will pass all through that sheet, from end to end of the ribbon, in the form of an ordinary or gentle contractile wave. On the other hand, whenever a *spasmodic* contraction is started in the nervo-muscular sheet by stimulating any of the marginal ganglia, it will pass all through that sheet, from end to end of the ribbon, in the form of a spasmodic or violent contractile wave. Hence the muscular fibres of this medusa are capable of liberating this energy in either of two very different ways; and whenever some of them liberate their energy in one of these two ways, they determine that all the other fibres in the nervo-muscular sheet shall do the same. So that we may adopt a far-fetched but convenient simile, and liken the muscular fibres in this medusa to the fibres in a mass of gun-cotton. For in a mass of gun-cotton the fibres are likewise able to liberate their energy in either of two very different ways—viz., either by burning in quiet flame when they are simply ignited, or by exploding in a violent manner when they are detonated, as by a percussion-cap. And both in the case of the muscle-fibres of *Staurophora* and the cotton-fibres of gun-cotton, whenever any one of the whole number is made by appropriate stimulation (i. e., muscular stimulation or ignition) to liberate its energy in a quiet manner, then all the other fibres in the mass do the same; whereas, if any one of the whole number is made by another appropriate stimulation (i. e., ganglionic stimulation or detonation) to liberate its energy in a violent manner, then all the other fibres in the mass do the same. Now why the ganglia of this medusa should thus act as detonators to the muscular fibres, and why, if they do, the muscular fibres should be capable of two such different kinds of response—these are questions quite novel in physiology, and as such I will not endeavor to answer them.

Poisons.—As my space is now very nearly exhausted, I will conclude this article by very briefly stating the general results of a large number of observations concerning the action of various nerve-poisons on the *Medusæ*. It is easy to see that this is an important branch of the inquiry on which I am engaged; for in the nerve-poisons we have, as it were, so many tests whereby to ascertain whether nerve-tissue, where it first appears upon the scene of life, is of the same essential character, as to its various functions, as is the nerve-tissue of higher animals.

Chloroform, ether, morphia, etc., all exert their anæsthesiating influence on the *Medusæ* quite as decidedly as they do on the higher animals. Soon after a few drops of the anæsthetic have been added to the water in which the *Medusæ* are contained, the swimming motions of the latter become progressively slower and feebler, until in a minute or two

they cease altogether, the animals remaining at the bottom of the water, apparently quite dead. No form or degree of stimulation will now elicit the slightest response; and this fact, it must be remembered, is quite as remarkable in the case of the *Medusæ* as in that of any other animal. Recovery in normal sea-water is exceedingly rapid, especially in the case of chloroform and ether.

The effects of strychnia may be best observed on a species called *Cyanæa capillata*, from the fact that, in water kept at a constant temperature, the ordinary swimming motions of this animal are as regular and sustained as the beating of a heart. But soon after the water has been poisoned with strychnia, unmistakable signs of irregularity in the swimming motions begin to show themselves. Gradually these signs of irregularity become more and more pronounced, until at last they develop into well-marked convulsions. The convulsions show themselves in the form of extreme deviations from the natural rhythm of this animal's motion. Instead of the heart-like regularity with which systole and diastole follow one another in the unpoisoned animal, we may now observe prolonged periods of violent contraction, amounting in fact to tonic spasm; and even when this spasm is momentarily relieved, the relaxation has no time to assert itself properly before another spasm supervenes. Moreover, these convulsions are very plainly of a *paroxysmal* nature; for after they have lasted from five to ten minutes, a short period of absolute repose comes on, during which the jelly-fish expands to its full dimensions, falls to the bottom of the water in which it is contained, and looks in every way like a dead animal. Very soon, however, another paroxysm sets in, and so on—prolonged periods of convulsion alternating with shorter periods of repose for several hours, until finally death puts an end to all these symptoms so characteristic of strychnine-poisoning in the higher animals.

Similarly, without going into tedious details, I may say in general terms that I have tried caffein, nitrite of anyl, nicotin, veratrium, digitalin, atropin, curare, cyanide of potassium, alcohol, as well as other poisons; and almost without any exception I find them to produce the same effects on the *Medusæ* as they severally produce on the higher animals. The case of alcohol is particularly interesting, not only because an intoxicated jelly-fish is a ludicrous object to observe, but also because the experiments with alcohol show how precisely the specific gravity of the *Medusæ* is adjusted to that of the sea-water. For if, after a jelly-fish has become tolerably well drunk by immersion in a mixture of alcohol-and-water, it is transferred to normal sea-water, the exceedingly small amount of alcohol which it has imbibed is sufficient to make the animal remain permanently floating at the surface of the water until it again gets rid of the alcohol by osmosis.

As my space is now at an end, I must postpone for the present my account of a number of other experiments which, in point of interest, though not in point of systematic arrangement, have a better claim to

statement than some of those which I have now detailed. It is impossible, however, in one article to treat of all the new facts which have been yielded by this research; so that by making the present article dovetail with the one which was previously published in *Nature*, and also with future articles on the same subject, I shall hope eventually to lay all the results before the general public.—*Fortnightly Review*.

POPE AND ANTI-POPE.[1]

BY PROFESSOR CARL VOGT,
OF THE UNIVERSITY OF GENEVA.

WHILE the political pope in Berlin and the clerical pope in Rome are trying to come to an understanding with each other, the controversy between the medical pope Virchow, of Berlin, and the zoölogical pope Haeckel, of Jena, is just beginning. First come speeches, then pamphlets, and very soon the heavy artillery of books will be brought into the line of battle, for such is the strategy of the learned and the tactics of the booksellers. The fray begins with Haeckel making a speech at the Congress of German Naturalists and Physicians at Munich; next, Virchow hits back at the same congress; then follows a sharp fire from the riflemen in the newspapers *pro* and *con*, according to the side they take; and, while this is going on, Haeckel sends into the field a pamphlet of one hundred pages, as a storming battalion. We have little doubt but that Virchow will answer with a volume twice as big, and this is all the more to be expected since, as it seems to us, the majority in this year's Congress of Naturalists (to judge from the speeches and lectures delivered at Cassel) leaned to the side of Haeckel. Then, too, the reception tendered to the two leaders in Paris, where Haeckel was lionized, while Virchow was treated not very kindly, will probably cause the latter to make another hostile movement.

Perhaps I ought to have entitled this article "Prophet and Schoolmaster," for, while Haeckel confidently advances with his hypotheses and phantasies, which he would fain palm off upon the public as "demonstrated truths," Virchow's manner is characterized by that schoolmaster air which is one of the prominent peculiarities of the Central Prussians, and especially of the Berliners. You cannot be in the company of a man of Berlin for a quarter of an hour without feeling that you are being corrected—in short, treated as a schoolboy; and the men of Berlin are surpassed in this respect only by the ladies. But, as in the two contestants, with whom we have here principally to deal, the sense of their own infallibility, which is the very note of the papal office, is specially prominent, and determines the whole tenor of their thoughts,

[1] Translated from the German by Gustav Miller.

the title given above may stand. True, it fares with their oracular allocutions and their *anathema maranathas* as with like utterances at Rome: though many bow their heads and blindly believe, still there are not a few doubters and unbelievers, and it is almost to be feared that the latter will form the majority.

The pith of the matter in dispute between these two men it is not difficult to get at: in short, it is Darwinism. Haeckel carries this theory to extremes; Virchow not only questions its legitimacy, but also insists that it may have applications that would imperil the state. The one wants to introduce the theory of evolution even into the schools, though, indeed, without knowing exactly how; the other would not only reject it absolutely, but he even anticipates Prince Bismarck by holding that Darwinism is in sympathy with democratic socialism; Haeckel tries to prove that the tendency of Darwinism is aristocratic rather; and, while Virchow sneers at the "souls of cells" and of "plastidules," Haeckel counters by affirming that these views are direct logical conclusions from the principle on which Virchow has staked his whole scientific existence, viz., that every cell originates from a cell (*omnis cellula ex cellula*).

I have already elsewhere expressed my views touching the quarrel fomented by Virchow, and have become only more satisfied of their correctness after reading Haeckel's pamphlet "Free Science and Free Teaching." While Haeckel has laid himself open to attacks by his exaggerations and by the brusqueness with which he has striven and still strives to impose his exceedingly poetical fancies upon others—a course of conduct which he will as surely regret later, as he now rues, according to his own confession, the "youthful extravagances" contained in his "Generelle Morphologie" and in his "Natural History of Creation;" while he makes inconsiderate and yet practical demands, without being clear about the possibility of their realization; nevertheless on the whole he represents truly the correct basis of freedom of science and of scientific teaching, so that one can without hesitation agree with his conclusions in that respect. Virchow, on the other hand, is the representative of the pedagogues' Philistia, which not only is proud of its ignorance, where ignorance is excusable, but which coolly denies everything that it does not understand, just as if it did not exist at all; and meanwhile appeals to the Church and to the police for aid against the practical application of scientific doctrines in the field of political action. Thus scientific research is to be free in the quiet of the study so long as there is no special statute to extinguish its lamp; but when it comes to the question of *teaching* science the situation is altered, and such a thing is not to be permitted save under restrictions.

Now, let us follow for a while the train of thought of Haeckel's counter-pamphlet. In the first chapter, entitled "Evolution and Creation," he compares the two theories, which, according to him, may be held concerning the origin of organisms, and, as I believe, of universal Nature:

Either organisms were evolved in a natural way, or they were created in a supernatural way, independently of one another. Haeckel, then, considers the evolution theory, first, as a universal cosmic idea, which assumes one causal law for all natural phenomena—the theory of descent, according to which all animals and plants are derived from simple primordial organisms; and, second, as the theory of natural selection (Darwinism in the strict sense), according to which the transformation of organisms has for its essential condition natural selection in the struggle for existence. And, by-the-way, we here find in Haeckel for the first time, if we are not mistaken, the admission that "the essence of the theory of descent is not affected, whether we postulate one or whether we postulate many common ancestral forms" (monophyletic hypothesis, polyphyletic hypothesis). It used not to be so, and whoever did not believe in the primordial mammal, the primordial amniote, the primordial fish, etc., was a lost man. In this admission we see the signs of a reaction from the monophyletic genealogies, which now fill whole volumes. Haeckel then tries to prove that Virchow is a believer in the creation theory, although he nowhere says as much openly. Virchow's expression, which Haeckel quotes, that "the scheme of organization within the species is immutable—like will beget like," is susceptible of more than one interpretation.

In the second chapter, entitled "Sure Proofs of the Theory of Descent," Haeckel rejects experiment as the highest means of proof, which Virchow requires; at the same time he asks: "What is there to be proved by experiments? What can experiment prove in this case?" But I must confess that I am not at all of his opinion. Haeckel is right in maintaining that the artificial breeding of our domestic animals, such as the horse, the pigeon, and the dog, and the culture of our garden-plants and culinary vegetables sufficiently demonstrate the mutability of species; that the forms purposely developed by us differ from one another far more than wild species do; that the evidence against the evolution theory, which was intended to be deduced from hybridization, is only empty talk, without sense, because several species do produce fruitful hybrids: but that the limits of experiment are here reached we can in no wise admit. Experiments like those made by Madame von Chauvin with salamanders can be repeated, not only with the lower vertebrates but also with the invertebrata, and must surely lead to very important results. I believe I can predict that the activity of working naturalists, as soon as the present rather artificial methods of hardening and dissection of organs and of whole animals, which reign now almost exclusively, shall have exhausted themselves, will be devoted to such experiments as have for their aim to prove that transformations, such as we see in Nature, can be produced at pleasure. To make this point clear, I will mention the eyeless cave-animals and parasites. To any one, however little familiar with the history of the evolution and the relations of these animals to others, they furnish a complete demon-

stration of the transformation of species once inhabiting open space and endowed with visual power into blind creatures with a very restricted range; but for men who, like Virchow, do not know these relations, the experimental proof might be given. Who will deny that such experiments would further science?

In the third chapter, "Cranium Theory and Ape Theory," Haeckel considers a familiar question, treated already by Virchow in a lecture delivered in 1869, on "The Crania of Men and Apes." Unfortunately, in regard to this very question, Haeckel has, by his extravagant theses, seriously weakened the ground on which he stands, if he has not swept it clean away. Once you say "Man is a true catarrhine monkey," then it is difficult to meet the swarm of objections that will be raised. Virchow's discourse was one of the weakest ever published on this subject, and, although the author directed his polemic chiefly against me, I have not seen fit to make any reply, because I should have had only to point out and meet a misunderstanding (whether intentional or not I will not decide) of what myself and others have said. Virchow himself, in that essay, declared that "the resemblance of young monkeys to human children is very much greater than that of old monkeys to adult and fully developed men;" but he is unable to see that this, and the fact that as they advance in age the differences become more pronounced, necessarily lead us to suppose a point of time in the remote past at which the two types developed in divergent directions. Haeckel, then, is perfectly justified when he says in his reply, "From this inevitable grouping results the *common* origin of man and monkey from *one* ancestral form;" and I observe with pleasure that here, again, Haeckel abandons his extravagant theses, and lays down propositions which must be regarded as entirely tenable.

Even if to me, as to Oscar Schmidt, Haeckel's doctrines concerning the "memory of the plastidules" and the "psychic activity of the cells" appear only as a "shipwrecked hypothesis," and not, as their author believes, "the sure foundation of empirical psychology," nevertheless, I must, on the other hand, admit that Haeckel simply demolishes Virchow's position in his fourth chapter on "The Cell-Soul and Cellular Psychology." That in the development of the psychic faculties of the organism we have the same process of perfectionment, the same division of labor, the same gradual differentiation, as in the development of the bodily organs and tissues, cannot be doubted; but when, at Munich, Haeckel asserts that we have in the several individual cells *the self-same* manifestations of psychic life, of sensation, and of thought (*Vorstellung*), of will, and of movement, which are seen in higher animals made up of many cells, he exaggerates; this exaggeration can, however, in part be accounted for by the fact that language possesses no terms to denote the obscure and in some sense *confluescent* expressions of these lowly psychic activities. But Virchow has the assurance to say to the assembled naturalists and physicians: "There is no doubt that, for us,

mental phenomena pertain to certain animals, not to the totality of all organized beings, nor even to all animals; this I maintain without hesitation. We have no reason yet to affirm that the lowest animals possess psychic attributes; these we find only in the higher animals, and with perfect certainty only in the highest." Verily, Haeckel is right when he says that any zoölogist, on reading this sentence, must throw up his hands in astonishment and ask, "Where would Virchow fix the point at which the soul suddenly enters the previously soulless body?"

But Haeckel deals his adversary a still more telling blow when, in the fifth chapter, "Genetic and Dogmatic Method of Teaching," he repudiates Virchow's theses touching the freedom of research and the restriction of the liberty of teaching. Virchow would have only objective knowledge taught in educational institutions. Haeckel, on the whole, only enlarges upon what I said in reply to Virchow eight months ago, when I gave to the Virchovian prescription this form: Give the student just so much as he requires to pass his examination and no more. As Haeckel justly observes regarding Virchow's suggestion that nothing should be taught which is not absolutely certain, all sciences, with the exception of lower mathematics, would have to be stricken from the lecture-list; and, as Helmholtz very properly remarks, it behooves us to declare that the teacher's work can never bear fruit, save inasmuch as it conveys to the student a conception of "how the thoughts of independent thinkers are moving."

The chapter entitled "The Theory of Descent and Social Democracy" is a brief one, because, as Haeckel tells us, the amazing denunciations pronounced by Virchow called forth from the moment of their publication the just indignation of thinking men, and were signally rebuked. It is a pity that Haeckel did not himself conform to the principle which he laid down toward the close of his chapter, where he says: "Wherein does all this concern the scientific investigator? His sole and only problem is this, to ascertain the truth, and to teach what he has recognized as true, without regard to what corollaries the various parties in state and church may draw from it." This was the right reply, nay, the only one, to make to Virchow's ill-judged utterance; but, instead of following it up, Haeckel endeavors to prove that the Darwinian tendency can only be aristocratic. A man can read in the book of Nature whatever he pleases, just as in the Bible; but Darwinism is neither socialistic nor aristocratic, neither republican nor monarchical; it is an explanation of the most diversified natural phenomena, but it rests on one simple principle. Such is Darwinism—nothing more, nothing less.

In the closing chapter, "Ignorabimus et Restringamur," Haeckel criticises Du Bois-Reymond and his speech made in 1872. Of this chapter we have only to say that we fully accept all that the author writes concerning the decline of natural science at the University of Berlin. How far ossification has advanced there, may be understood when we reflect that the chair once filled by Johannes Müller is to-day occupied by

Reichert. Formerly in Hesse the pay of parsons was attached to the cure. The result was, that good parishes always fell only to worn-out parsons, deserving, indeed, of promotion, but who could no longer render much service. Berlin is steadily approaching the same state of affairs. It is a pity that German universities cannot be dissolved every thirty years and manned anew! Perhaps some life would then flow into those places of refuge, where the scientific big-wigs rest from the toils of their youthful years!

SCIENTIFIC RELATION OF SOCIOLOGY TO BIOLOGY.[1]

By Professor JOSEPH LE CONTE.

I.

THE Hierarchy of Science.—There is a well-recognized scale in the hierachy of sciences. In the ascending order the steps are —mathematics, mechanics, physics, chemistry, biology, and geology. Mathematics deals only with space and time, number and quantity; and is therefore independent of matter and force. All other sciences deal also with matter and force, and are therefore properly called natural sciences, but they individually deal with different forms of matter and different grades of force. For example, the physical sciences deal only with those universal phenomena produced by physical forces; chemistry, in addition to these, deals also with a higher but more limited and special group of phenomena, determined by a peculiar force —chemical affinity; biology, in addition to all the preceding, deals also with a still higher and far more limited and special group of phenomena produced by a still more characteristic force—*life*.

The order of forces and phenomena-groups given above is, as we see, the order of increasing complexity and of increasing specialty, and therefore is also the order of their appearance in the evolution of the cosmos. There can be no doubt that physical forces and their associ-

[1] The views here presented were first embodied in the form of a lecture in 1859, and published in the *Southern Presbyterian Review* in April, 1860. They are now rewritten and condensed, the order of presentation entirely changed, and some new thoughts added. I mention this only to show that they are largely the result of independent thought—for they antedate the recent literature on the subject of sociology, as also Darwin's work on "Origin of Species." This re-presentation has been affected by Darwin's work only in one point, viz., the introduction of the principle of survival of the fittest. To two authors only I acknowledge large indebtedness. To Comte I am indebted for the general idea of a scientific connection between sociology and biology. To Agassiz I am indebted for a clear conception of the characteristic doctrines and methods of biology. In fact, all the *formal* laws of evolution, as now recognized, were announced by him, although he did not accept the origin of species by derivation. For the application of these laws to sociology, and for the mode of presentation, I am alone responsible.

ated phenomena appeared first, then chemical, then vital, and, lastly, rational (if these can be at all considered in the same category). It is also the order of dependence, and therefore, also, of historic development of the sciences based upon them. Mechanics is absolutely dependent on mathematics, and must, therefore, have awaited its development. Similarly, physics is dependent on both mathematics and mechanics, but especially the latter, and therefore must await its development. Similarly, chemistry must wait on all the preceding, but especially on physics; and biology must patiently await the development of all the preceding, but especially of chemistry.

But observe the following qualification: This is the necessary order in which these departments *take on true scientific form*, but not necessarily the order in which they are first commenced to be cultivated. Astronomy commenced to be cultivated by the Chaldeans long before mathematics or mechanics was sufficiently advanced to be applied to it. Biology commenced to be cultivated by Aristotle, or perhaps even by Solomon, long before chemistry and physics were sufficiently advanced to be of any use in biological investigations, and indeed before these sciences were born. In all sciences, but especially in the higher and more complex departments, there are three distinct stages of advance: The first consists in the observation, collection, and arrangement of facts—*descriptive science*. The second is the reduction of these to formal laws—*formal science*. Thus far the science is independent of other sciences. The third is the reference of these laws to the more general laws of a more fundamental science—in the hierarchy as their *cause*—*causal science*. It is this last change only which necessarily follows the order indicated above. Its effect is always to give great impulse to scientific advance; for then only does it take on the highest scientific form, then only does it become one of the hierarchy of sciences, and receives the aid of all. Thus to illustrate: Tycho-Brahe laboriously gathered and collated a vast number of facts concerning planetary motions—descriptive astronomy. Kepler reduced these to the three great and beautiful laws known by his name—formal astronomy. But it was reserved for Newton, by means of the theory of gravitation, to explain the Keplerian laws by referring them to the more general and more fundamental laws of mechanics as their cause, and thus he became the founder of physical or causal astronomy. In other words, astronomy was first a separate science based on its own facts. Newton connected it with mechanics, and thus made it one of the hierarchy. From that time astronomy advanced with increased rapidity and certainty. Astronomy first rose as a beautiful shaft, unconnected and unsupported, except on its own pediment. In the mean time, however, another more solid and more central shaft had grown up under the busy hands of many builders, viz., mechanics. Newton connected the astronomical shaft with the central column of mechanics, and thus formed a more solid basis for a yet higher shaft.

CHARACTERISTIC IDEAS.—Such, then, is the hierarchy of science and the mutual relations of the several orders. Now, each group of sciences, as Whewell has shown, has its own characteristic fundamental *idea* or *ideas*. For example, the fundamental ideas of mathematics—the ideas underlying all its operations—are those of *number* and *quantity*. The fundamental idea of mechanical and physical sciences is that of *physical force*. The fundamental idea peculiar to chemistry and underlying all its distinctive phenomena is that of *affinity*. The fundamental idea underlying all the distinctive phenomena of biology is that of *life*. Subordinate ideas under these general heads we shall call, after Comte, *doctrines*.

CHARACTERISTIC METHODS.—Again, each group of sciences has also its *characteristic method*. The characteristic method of mathematics is that of *notation*. We are all familiar with the wonderful power of this method. By the use of a few figures, viz., the numeral digits, having each a value of its own and another depending on position, a few symbols, a and b, x and y, connected by signs, $+$ and $-$ and $=$, the veriest schoolboy may quickly solve problems which would defy the unassisted efforts of the greatest genius. The characteristic method of physics and chemistry is *experiment:* without the use of this potent instrument these sciences could not advance a step. The characteristic method of biological sciences is the *method of comparison*. The use of this method we will illustrate after a while.

Now, each group, after it once enters the hierarchy, besides its own characteristic ideas and methods, uses freely and with the greatest advantage all the ideas and methods of the lower sciences, but especially those of the science immediately below, and with which, therefore, it is immediately connected. Thus chemistry uses the characteristic ideas and methods of physics and mathematics, but especially of physics. Biology, besides its own characteristic ideas and methods, uses freely the methods and ideas of chemistry—physics and mathematics—but especially those of chemistry. If there be any other still higher science, it must use with the greatest advantage the ideas and methods of all lower sciences, but especially those of biology.

Again: although the ideas and methods of the lower groups are imported into the higher groups and freely used there, yet we acquire clear conceptions of such ideas and doctrines, and expertness in the use of such methods, only in the group where they are native and characteristic. Thus, each group of sciences becomes the appropriate school for its own characteristic doctrines and methods. For example, physics uses freely the method of notation, but mathematics is the true school of this method. Biology uses experiment, but physics is the true school of this method. If there be any other still higher science which shall use the doctrines of life and the method of comparison, the cultivators of that science should first acquire clear concep-

tions of these doctrines, and learn expertness in the use of this method by the previous study of biology.

Now, there is, or shortly will be (for it is scarcely yet organized), a science far higher than any yet mentioned—a science which is the crown of human knowledge—a science to which all others are subsidiary—sociology. I wish to show the close connection between this science and biology. I wish to show that it only becomes truly scientific by being connected with biology, and thus placed at the head of the hierarchy. I wish to show that whatever of recent advance has been made in this science has been made by the application of the characteristic doctrines and methods of biology. I wish to show that biology is an important—yea, more, the most important—preparatory school for the study of sociology.

Biological Ideas applicable to Sociology.—As already stated, the fundamental idea of biology is life. Under this general idea there are two subordinate ideas or doctrines, viz., *organization* and progress by *evolution*. Life is maintained through an *organized structure*. Life advances from lower to higher grades by *evolution*. Now, is not society, too, endowed with life? Is not the social life maintained by organization; and does it not advance from lower to higher grades by a process of evolution? Let us examine in more detail:

1. *Organization*.—A living organized structure, or an organism, may be defined as a structure consisting of many different parts, having different forms, and performing different functions, but all coöperating to one given end, viz., the life, growth, and development, of *the whole*. The animal organism is composed wholly of cells, as a building is of bricks; all animal functions are performed by cells; growth is continual formation of new cells; reproduction is the separation of cells to form a new colony of cells. But the constituent cells of an organism, especially one of the higher organisms, are not all alike. On the contrary, they are as diverse in form as they are in function. The many functions of the body are parceled out among the cells by division of labor, and thus there results an absolute mutual dependence of parts. So society, also, is composed of many structural elements (individuals), having different pursuits, i. e., performing different social functions, and therefore mutually dependent, but all coöperating to maintain the life of the whole. Society, therefore, is in some sense an organism and subject to the laws of life and organization.

Again, as in the animal organism, the structural elements, the cells, are far more numerous than the functions: many cells of similar form aggregate to form *organs*, all the cells of one organ coöperating to perform its function, and all the organs coöperating for the life of the whole organism. So in the social organism, the structural elements (individuals) being much more numerous than the social functions, many individuals of like pursuits or functions aggregate into corporations, professions, trades-unions, etc. These are the organs of

the social body. They ought to coöperate for the welfare of the whole.

2. *Evolution.*—All the laws of evolution which have been discovered in organisms apply also to society, but with certain *limitations*, which I believe are very significant.

(*a.*) *Law of Differentiation.*—The most fundamental law of evolution is *differentiation.* The organism, as I have described it above, with its cells of diverse forms and functions, was not thus constituted in the beginning of its existence, but gradually became so by a process of differentiation. In the early stages of an organism the constituent cells are all *alike* in form, and each performs, though imperfectly, *all* the functions necessary in this early stage. But, as the organism develops, the cells begin to take on different forms, and to perform different functions, and this process of differentiation continues until, in the mature condition of the highest organisms, each group of cells (or each organ) is limited to the performance of one function only. This one function is its only evidence of life. Now, concurrently with this increasing differentiation of form and limitation of function, there is, of necessity, an increasing mutual dependence of parts, and a sacrifice of the independent life of the part to the common life of the whole. In the lowest condition of the organism, where the cells are all alike, and each performs, though imperfectly, all the functions, there is a very considerable, sometimes a complete, independent life in each cell; so that it may be separated without injury either to itself or to the community of cells: the independent life is large, the common life is feeble. But, as we rise in the scale of organization, the independent life of the part is merged more and more into the general life of the whole—is sacrificed, and goes to make up the common life—until, in the mature condition of the highest organisms, the independent life of the constituents is reduced to a minimum, while the common life is advanced to a maximum. This complete merging of the independent life of the part into the common life—this identification of life with function—is the *ideal of the animal organism:* the nearer it approaches this condition the higher manifestly is the organism.

Or take instead that larger organism, more nearly resembling, and therefore better illustrating, the social organism, viz., the *whole organic kingdom—its* present diverse condition has been reached also only by a process of differentiation. Commencing in the earliest times, with similar and independent beings, by a continual process of separation and differentiation, animal forms have become more and more diverse, occupying different places and performing different functions in the economy of Nature; the higher becoming still higher, and the lower becoming lower; the mutual dependence and interaction of all parts becoming greater and greater, until the ideal seems almost reached in the present fauna and flora. If we can conceive any organism still higher than man, or lower than the monera—if we can conceive a re-

lation and interaction between the different kinds constituting a fauna and flora still more complex, and a struggle for life still fiercer than now exists, then is the ideal not yet reached.

So society, also, has reached its present highly-organized condition only gradually, by a process of differentiation. In the early stages of society the constituent elements are all alike, and each performs, though in an imperfect manner, all the social functions necessary in this early condition. As society advances, the pursuits of man become more and more different, the social function of each more and more limited, until each is confined to *one* social function only. Concurrently with this differentiation of pursuits, the independent life of the constituents, absolutely perfect at first, is merged more and more into the common life of society, with increasing mutual dependence, as in the animal organism; and yet, alas! with increasing selfish antagonism and competitive struggle for life, as in the organic kingdom. Here, too, from the purely material point of view, the ideal, as in the animal organism, is complete loss of independent life—the complete merging of the individual independence into the common life of society—the identification of individual life with social function. Here, too, from the same point of view, the ideal, as in the organic kingdom, is the highest high and the lowest low, and the extremest diversity. The higher becomes the high, the lower sinks the low, and the more extreme the diversity—the more complete the loss of individuality and merging of constituent life into social function—the more perfect the mutual dependence, and yet the fiercer the antagonism and struggle—the nearer do we approach the ideal. This is manifestly the ideal of material organization, and therefore of society, from a purely material point of view. If this ideal is not only undesirable but impossible—if our whole better nature shrinks aghast from its realization—it is because it takes no cognizance of our higher and distinctively human nature, i. e., our spiritual or moral nature; it is because the law of our spiritual or moral is different and even antagonistic to the law of our animal or material nature. The relation of material units is by mutual dependence, and yet antagonism: the relation of moral units is by mutual sympathy and love. The existence of a moral nature limits the laws of a purely material organization. The essential difference, therefore, between the animal organism and the social organism is that, in the former, the constituents exist only for the community, while in the latter the community exists only for the constituents. This transcendent value of the constituents is manifestly the result wholly of the moral or spiritual nature of man.

There are, then, three stages of social advance: 1. *Gregariousness*, or loose, *unorganized* association of *similar* constituents: this corresponds in biology to the simplest form of cellular aggregation. 2. Gradually increasing differentiation and consequent merging of the constituent life into the common life by limitation of function, and

therefore mutual physical dependence, until the constituent life is finally identified with the social function: this corresponds with the *ideal* of material organization. 3. The *reassertion* of the independent personality of the constituents, and the alliance of these by *moral* instead of physical bonds—by mutual love instead of mutual dependence: this has no correspondence in material organization, since it becomes possible only through a higher nature than the material. There are, therefore, two modes of subordinating the individual life to the race—one by mutual dependence, the other by mutual love. The former destroys our personality, the second enhances it. He who loses his independent life by the first method, loses it irretrievably; he who loses it by the second method, shall find it again. The former is the ideal of material organization, and has been partially attained in many forms of society, ancient and modern; the latter is the ideal of Christian civilization. Society is even now in a state of transition between the two.

(*b.*) *Progress.*—The more fundamental law of differentiation limits, and in the minds of many persons confuses, the idea of progress. Progress as a law of evolution does not imply advance to successively higher points along every line and in every part; but only that the highest parts become successively higher, and the whole becomes successively greater. The constituent parts of a developing organism, starting from a common level, are some of them advanced to the dignity of brain-cells, and become the instruments of *thought*, while others sink to the condition of kidney-cells, whose function is only to secrete *urine*. But the highest cells become higher and higher, and the whole organism becomes greater and more complex.

Again, in the development of the organic kingdom, from the earliest geological times until now, if we could trace the several lines of genetic descent, we would doubtless find as many examples of retrograde as of advance movement. This fact has given rise to most of the dispute concerning the existence or non-existence of a law of evolution in the organic kingdom. This dispute is mostly the result of a misapprehension of the law of evolution. In the process of differentiation of the organic kingdom from a common level, the lines of descent went some upward, some downward, some sideways, every way and any way to reach some unoccupied place and subserve some different function in the economy of Nature, but the dominant classes became successively higher, and the whole organic kingdom successively greater and more highly organized. The tree of life sent its branches, some upward, some sideways, some downward, any way and every way for room and light, but its top went higher and ever higher, and its whole clustering branches became broader and ever broader.

So is it in society: if we could trace all the lines of genetic descent, starting from a common level, some would go upward, some downward, some this way and some that; in *social* function some would advance to the dignity of philosophic thinkers—the teachers of the race—and

some would sink to street-sweepers and sewer-cleansers. But the highest went progressively higher, and the whole became progressively grander. We are saved from the real as well as apparent degradation of these lower functionaries, only by the fact that the constituents cannot in the social organism, as they can in the material organism, be identified with and merged into their functions. Man has, fortunately, many other functions besides his *social* functions, viz., those higher functions connected with his moral nature.

In all progress, therefore, and as a necessary consequence of the law of differentiation, there is a straight and very narrow way, from the lowest to the highest, or ideal. Thus, in the progress of the organic kingdom from the lowest eozoön to the final term, the ideal, of material evolution—man—there is only one straight and narrow way onward and upward. Any turning off from that way leads, perhaps, to some other excellence, but not toward the highest—not toward man. Once leave the straight way, and there is no getting back upon it. Progress goes on, but only on the path chosen. The law, so far as material evolution is concerned, is inexorable. The tree of evolution has but one straight, ascending trunk leading upward to its terminal bud. A growing-point, once separated as a branch, continues, indeed, to grow, but only on its own way.

The same is true of higher forms of evolution. The progress of evolution of the organic kingdom, completed in man, is immediately taken up by man and carried forward on a higher plane in social evolution; and here, again, we find the same law. In the progress from primitive man to the condition of the most cultured races, there has been but one straight and narrow way. Those nations who by differentiation turned off from that track, have gone each their separate way—some this, some that—but cannot get back, or have not yet got back, on the true line of progress toward the highest. I do not say, however, that it is impossible to get back, for Reason again comes in to modify the material law and to confer plasticity on the nature of man.

The same law, again, appears epitomized with terrible significance in the history of each individual human soul. In the progress of the human spirit from childhood to the highest ideal of intellectual and moral culture—the Christian ideal—there is the same straight and narrow way. If we turn off from that way, it is easy to go on, but alas! how hard to get back! But for the modification of material laws by the presence of a higher law, it would be impossible.

(*c.*) *Cyclical Movement.*—In all evolution the progress which we have illustrated under the last head advances not at uniform rate, but in a succession of cycles by the rise, culmination, and decline, of higher and still higher dominant functions, principles, ideas, etc. Thus, in the individual human organism, there rise, culminate, and decline, first in childhood the *nutritive* functions; then in youth and early manhood, the *reproductive* and *muscular* functions; and, lastly, in full maturity,

the *cerebral* functions. Or, in the development of the mind, there rise, culminate, and decline, first in childhood, the perceptive faculties and the memory; then in youth and young manhood, the imaginative and æsthetic faculties; then in full manhood, or even beyond, the faculty of productive thought; and, finally, only late in life, and if the life has been noble, the moral and religious nature: the first, gathering and storing the materials for intellectual growth; the second, warming, vivifying, vitalizing, the materials thus gathered; the third, using them in constructive mason-work—in building the temple of science and philosophy; the last beautifying and ennobling that temple and dedicating it to holy purposes, thus connecting the evolution of the spirit in this life with that which, as we hope, continues in another. Similarly, in the development of that greater organism, viz., the organic kingdom, we have the rise, culmination, and decline of successively higher and higher classes of organisms: first of mollusca, then of fishes, then of amphibia, then of reptiles, then of mammals, and, finally, of man. And here, too, in the last step we find again the lower or animal evolution connected with and continued by a higher, viz., the social evolution.

So is it also in society. Here, too, we find progress is accomplished by a successive rise, culmination, and decline, of higher and higher dominant ideas or principles, determining different phases of civilization. The law may be traced not only in the general civilization of successive epochs, but even in the component parts or principles of civilization. It is not only cycle beyond and above cycle, but also cycle within cycle. Thus we have successively culminating and declining Egyptian, Greek, Roman, and now rising but not yet culminating, modern civilization, confessed by higher and higher forms. In natural religion we have everywhere first fetichism, then polytheism, and then monotheism. In the direct line of modern religious organization we have the Jewish and the Christian form. In the Christian Church we have the primitive or apostolic form, the Roman form, the Protestant forms, and we yet hope for a still higher and more rational form in the future.

But, observe: in all development, when a dominant function, faculty, principle, etc., declines, it does not perish, but only becomes subordinate to the next rising and higher dominant function or principle, and thus the whole organism becomes not only higher but also more complex. Thus, when the perceptive faculties and memory decline in early manhood, they do not perish, but only become subordinate to the higher dominant imaginative and æsthetic faculties characteristic of that age. Again, when these latter decline they do not perish, but only in their turn become subordinate to the still higher faculty of productive thought, which in its turn, and with it the whole character, becomes subordinate to the moral and religious nature. Thus the perfect man does not forget utterly the things of childhood and youth and early manhood, but

incorporates all that is best in each, and subordinates them to the highest; and thus the whole character becomes broader and more universal in its sympathies, as well as higher. This is the true type of culture —for culture is naught else than a natural evolution assisted by art. True culture does not educate us out of sympathy with childhood and youth, nor above sympathy with the lower classes of society; it does not simply raise us pygmies on a platform above the heads of our fellow-men, but without increasing our stature. If our culture does so, it is a false culture. The true cultured man stands on the same common level with other men, only his higher parts rise higher. But see the necessity which this law lays upon us of never-ceasing culture! Beautiful, joyous childhood cannot last, must decline. If we do not cultivate the higher imaginative and æsthetic faculties, our nature inevitably deteriorates from that time. Glorious youth and young manhood must decline, and with it our whole nature must deteriorate if we do not cultivate reflective and productive thought. Lofty intellectual power must also decline. Alas! how sad to see in old age the whole character deteriorate for want of moral and religious culture, which alone insures immortal progress!

The same law holds equally in the development of the organic kingdom. When the class of fishes declined in power, it did not perish, but became subordinate to the incoming higher dominant class of reptiles, which, in its turn, sought safety in subordination to the still higher incoming class of mammals, and this in its turn to the highest dominant class, *man*; and thus the whole organic kingdom becomes not only higher, but also broader, more complex, more diverse.

So, also, in society. When any dominant idea, principle, or social force of any kind, characteristic of any phase of civilization, declines, it does not perish, but becomes incorporated into the next higher phase of civilization as a subordinate force or principle. Thus each age incorporates what is best in the previous age, and modern society is the resultant of all the social forces which have acted from the beginning—is the heir of all the ages; and the social organism has thus become not only higher, but broader, stronger, and more complex. And here, again, the same necessity is laid upon us, of continuous progress or else of decline. No mere phase of civilization can last, no social force can continue in its pristine power. That nation which refuses to accept the incoming principle is left behind and inevitably decays.

Observe again: the speediness of the rise, culmination, and decline —the short-livedness—of any phase of civilization is in proportion to the limited character of the principles involved—the partialness of the embodiment of all the principles of our humanity. As society becomes more complex, its cycles become longer, until it reaches continuous, steady progress—immortality—only in the complete embodiment of an ideal humanity. Such we believe is the ideal of a Christian civilization.

Observe again: in all forms of development the culmination and decline are in *strength* rather than in *quality*. This is only another mode of expressing subordination to a higher force. The perceptive and imaginative faculties, indeed, decline in strength and vigor as age advances; but they steadily progress in refinement, if intellectual culture continues. If, for example, relish for art is more intense in youth, it is also more gross. If it declines with age, it becomes also more refined, more discriminating, higher—i. e., it becomes subordinated to higher faculties. The same is true of development of the organic kingdom; for, when a dominant class declines, it declines in *strength*, not in organization. So, also, is it in society. The principle of chivalry, for example, culminated in the middle ages. It has since declined in strength, but gained in refinement; lost in quantity, but gained in quality. It has become less fantastic, less extravagant, less affected; more rational and genuine. In other words, it has become subordinated to still higher principles.

Observe again and finally: this idea of progress of society by cyclical movement is comparatively modern, and even yet imperfectly apprehended. Whence did it come? We see no evidence of it among the ancient Egyptians, Greeks, or Romans, nor among modern Chinese or Japanese. None of these could conceive any civilization higher than their own. None of these dreamed of an onward progress of the whole race, of which their own civilization was only one temporary phase. The Jews had it not. They could not conceive of their religion and polity passing away. Is it to be wondered at, therefore, that they rejected Christ, who preached the unheard-of doctrine of the introduction of a new era? The idea was, in fact, first announced by Christ himself, when he taught that the Jewish polity and ritual must pass away, and *yet the law be fulfilled;* that the form is temporary, but the spirit eternal; that the form dies, but the spirit must take on higher and higher forms. Until that time it is doubtful if the idea of any scheme of religion or politics being a temporary phase of civilization, and therefore passing away by the very law of human progress—the idea that the forms of the social body like the forms of the animal body are necessarily temporary—ever entered the human mind. How imperfectly it is yet apprehended, even by the most advanced peoples, is plainly shown by the history of both church and state. Immutable forms have ever been asserted and maintained by force until violently broken and thrown off by revolution. This great law is now generalized and made a universal law of all evolution only by biological research.

(*d.*) *Survival of the Fittest.*—The survival of the fittest, in the fierce struggle for life, is the best known and most universally recognized factor of the evolution of the organic kingdom. The manner in which this factor operates especially in successive differentiation, and the increasing specialization of each differentiated form, in causing the

tree of life to branch and again branch continuously, each branch pushing its shoot as far as possible in its own direction, are well understood. The gradual but steady improvement, the strengthening of the blood, increasing the energies, sharpening the instincts by ruthless destruction of the weak, the slow, the dull, the unfit in any way, and thus adapting the remaining strong and active in the most perfect manner to the various and varying conditions of life, is also clear. This pitiless principle acts among animals *without limit* except in the case of the young of the higher animals, and its good effect is just in proportion to its pitilessness.

Now, in human society, also, the same principle must act and does act as a powerful agent of progress, *but not without limit*. There is here introduced a higher moral or spiritual law which limits and modifies the operation of the material law inherited from the animal kingdom—a law which seeks the survival and improvement of *all*. As animality gradually developed into humanity (if we accept this view), this new principle of benevolence and mutual help was added to the old principle of selfism and mutual antagonism inherited with the animal nature. A new principle of altruism (as it is now fashionable to call it) was added to the old principle of egoism, in small proportions at first, but gradually increasing in strength as humanity is developed. Under the influence of the Christian ideal this principle has become so active in modern society as to seriously impair the healthy operation of the more fundamental principle of the struggle for life. There is little doubt that the survival of the weak and helpless, and the sustentation of the unfit and the vicious, are beginning to poison the blood and paralyze the energy of the race. Also the survival of so many who would be eliminated by the operation of the old principle, increases the pressure of population on the means of subsistence, and thus also increases the evil. How shall we, then, settle the claims of these two opposite principles—the one necessary to the physical, the other to the moral improvement of the race? It is evident that Reason must hold the balance, adjust the equilibrium, and repair any damage which has already resulted. This she will eventually do by pointing out and enforcing simpler and more rational modes of life, by sanitary regulations, and by proper physical education. Thus will it gradually restore and increase the vigor of the race. It will undoubtedly also prevent the pressure of increasing population upon the means of subsistence by limiting reproduction by rational, healthy, and moral methods. I call special attention to this as another example of the limitation or even reversal of a purely material law by a higher law connected with our spiritual nature.

BLACK DIAMONDS.

By M. F. MAURY.

AS we sit by our firesides and peer into the glowing coals, or watch the bright jets of flame spring into existence to throw their cheery light into the room, making weird, fantastic shadows on the wall, and bringing with them such comforting cheer to our senses of sight and feeling, we are often brought into very reflective moods, especially if we are sitting in the twilight, while the cold wind is whistling, and the sharp snow and hail of winter are clicking against the windows. But how very few think, or care to know, whence comes this black substance that adds so much to the comfort and ease and luxury of life! Yet an account of its uses and its history and the story of its formation are instructive in the extreme, and as interesting as those two great subjects of the day—the telephone and the phonograph. Why the former excites so little comment, and the latter so much, can be easily explained, for we were born and raised with the blessings and comforts of the one, and they are of such every-day occurrence as not to excite attention; while the others, though less beneficial to the race, are so new and startling in their wonders, that they at once claim our thoughts and make us eager to learn of them and their progress.

There is no one substance in all Nature that has done more to ameliorate the condition of mankind, to build up the pride and strength of nations, to convert the world from barbarity to civilization, or add more to our ease and luxury, than this black and uninviting-looking mineral. Through its agency in producing the motive power for machinery in the steam-engine, the wild places of the earth are penetrated, men have ready and quick transit thereto, all the benefits of civilization flow in, cities spring up, the husbandman has facilities for sending his surplus produce to the markets of the world, and waste places are made to blossom like the rose. Those nations that possess it in the greatest abundance and purity are those that rise the most rapidly to the highest and mightiest positions; for it is the mainspring of all manufactures, and it carries the products of such to the consumers in distant countries, across the trackless waste of waters, with a certainty and speed unattainable by any other means; it enables nations to stretch forth their armies and navies with such promptness that insults are followed by speedy retribution, and invasion met or guarded against. The light for our homes and cities, the most beautiful and delicate dyes for clothing fabrics, and the ink that prints our books and papers to scatter knowledge through the world, all come from the products of its distillation. In all the power exercised by it, it works greater wonders than the magician's wand in the "Arabian Nights;" in its

beneficial effects to mankind, it may be said, like mercy, to shed its gentle dews from heaven; and, by being the prime cause of annihilating distances, it has brought the human race closer together, and is thus the "one touch of nature that makes the whole world kin."

It is not only the most useful but it is the most valuable of all minerals, on account of the wealth that is produced through its agency. It is well understood that money is a sequence of work, and a community that has small labor-bills can take the trade away from those that have to pay high rates. Let us, therefore, see what work this substance can produce.

In mechanics the unit of work is the power necessary to raise one pound one foot high, and this is known as a *foot-pound*. From numerous experiments and observations, an able-bodied man, in working ten hours a day, exerts an average force of 1,000,000 foot-pounds. When coal is burned under a boiler it produces steam, which in turn produces work as it drives machinery. Therefore, coal produces work, the amount of which will vary according to the perfection of the machinery and the appliances for generating the steam. If we take an average of all kinds of engines, one pound of coal will produce steam sufficient to exercise a power of 500,000 foot-pounds. Hence the work accomplished by two pounds of the fuel equals a man's day's work. Now, mark the surprising results to which this leads us. The population of the United States is about 40,000,000, and in 1877 we produced 50,000,000 tons of coal. If one-fourth of this were applied to manufacturing, etc., it would do as much work as our whole population, assuming them all to be able-bodied men, in 350 days. The coal at the engine will average about four dollars a ton, while the price of unskilled manual labor can be put down at one dollar a day. Applying these figures, we see that the work in the first case would have cost $50,000,000; while in the latter, were it even possible to employ so many men, the labor-bill would have been $14,000,000,000! Can any one for a moment question the advantage or the value of the substance?

In these days, accustomed as we are to its multitudinous uses, it is difficult to imagine ourselves in the position of the early writers, who touched with uncertain pen on what they thought to be the leading characters of a rare and ambiguous mineral, or to conceive that its introduction was accompanied by such prejudice and superstition that laws were actually passed forbidding its use by the very countries that now consider it as the greatest of their possessions. In fact, it is of comparatively late date that it has sprung into the important position which it now occupies.

The earliest express mention made of it as a fuel was about 300 B. C., in the writings of Theophrastus, the pupil of Aristotle, who speaks of it as being found in Liguria (now the province of Genoa) and in Elis on the way to Olympias, where it was used by smiths. *Ampelitis*, a black stone "like bitumen," is mentioned by Pliny as available for

medicinal purposes. It has been attempted to show that the ancient Britons used it, but there is no satisfactory evidence on the subject prior to the later days of the Roman occupation, and it is not until the thirteenth century that we obtain clear proof that it was systematically raised for fuel in England. In December, 1239, King Henry III. granted a charter for this purpose to the townsmen of Newcastle-upon-Tyne, and the coal soon found its way to London; but the complaints against it became so great, as it got to be more and more used, and the city more smoky, that in 1306, on petition of Parliament, "King Edward I. by proclamation prohibyted the burneing of sea coale in London and the suburbs to avoid the sulferous smoke and savour of the firing, and commanded all persons to make their fires of wood" (Stow). Nevertheless in about fifteen years it effected a lodgment even in the royal palace, for in 1321–1322, in the "Petitiones in Parliamento," a claim is made for ten shillings on account of fuel of that sort which had been ordered by the clerk of the palace, and burned at the king's coronation, but neglected to be paid for.

On the Continent of Europe the earliest coal known was in the tenth century, in the coal-basin of Zwickau in Saxony, but in 1348 the metal-workers of that town were forbidden to pollute the air with coal-smoke.

In England, in 1577, an old writer (Harrison), in contrasting the burning of coal in chimneys and of wood without them, alludes to this prejudice when he says: "Now we have many chimnyes, and yet our tenderlings complain of rewmes, catarres and poses; then had we none but reredoses, and our heads did never ake. For as the smoke in those days was supposed to be a sufficient harding for the timber of the house, so it was reputed a far better medicine to keep the good man and his family from the quacke or pose, where with, as then very few were acquainted. There are old men yet dwelling in the village where I remain, which have noted the multitude of chimnyes lately erected, whereas in their yoong days there was not above two or three, if so many, in the most uplandish towns of the realme, but each one made his fire against the reredose in the halle where he dined and dressed his meate." In 1632 the historian, Stow, remarks, that "within thirty years last, the nice dames of London would not come into any house or roome where sea coales were burned, nor willingly eat of the meate that was either sod or roasted with sea coale fire." In some parts of France the prejudice against the fuel extended even to within our own day—in 1840—for St. John, in his "Journal of a Residence in Normandy," mentions that Dr. Bennett, a Protestant clergyman, told him that "he had received orders to quit his house, *because he burned coal;* and another English gentleman at Caen, who had invited a large party, finding his drawing-room very thin, and inquiring the reason, found that the French had staid away *because it was understood he burned coal.*"

These latter, however, are isolated cases, for we see that its economy as a fuel gradually beat down prejudice and opposition, and the consumption steadily increased; but up to the beginning of the eighteenth century the only purpose for which it was used was for the production of *heat* in houses. It was now to enter upon its second grand phase of usefulness—that for the generation of *force*, as manifested through the agency of the steam-engine, which was first used for mining purposes. By this application of steam not only was the mining of the coal made cheaper, but the facilities for distributing it enlarged, and as engines were improved from time to time, their number increased, because they could be economically employed in a greater number of industries, and therefore the demand for this class of fuel rapidly extended.

About 1805 *light* established a new market and demand for the black diamonds. For a hundred years or more there were various experiments on the distillation of coal in order to produce tar and oils, while the practical application of the invisible gases that were set free was not thought of till 1792, when William Murdoch, engineer to Bolton & Watt, employed coal-gas for lighting his house and offices, at Redruth in Cornwall. The earliest application of this light, on a large systematic scale, was in Manchester, where an apparatus for illuminating the cotton-mills of Messrs. Phillips & Lee was fitted up in 1804 and 1805, under the direction of Mr. Murdoch. This new invention rapidly spread, and in 1807 public streets were thus lighted. During 1877 the gas companies in New York City and the immediate vicinity alone required about 450,000 tons.

At Coalbrook Dale, in England, between 1730 and 1735, Abraham Darby made successful experiments in substituting coal for charcoal, in the manufacture of iron, in the blast-furnace, and thus made the first step in an industry that now requires millions of tons annually; though it was not till 1830 that this trade really began to assume the gigantic proportions which it now has. At that date Neilson, in Scotland, applied the *hot-blast* to iron-furnaces, for the purpose of economizing fuel, and succeeded so well that a ton of coal now reduces three times as much iron as it did before. This, like all other inventions tending to economy, increased the manufacture of iron, and consequently demanded more fuel, exactly as the merchant finds it to his advantage to have quick sales and small profits.

During the last twenty years chemistry has discovered many minor but none the less striking applications of coal in utilizing the once waste products of its distillation for gas. Among these may be cited solid paraffin, which, when made into candles, equals in beauty those of wax; from its analine are obtained many of the most exquisite dyes, whose shades and tints please the eye and gratify our tastes; it seems almost past belief that some of the delicate toilet perfumes come from it, and that flavoring extracts to pander to our palates are distilled from the same black substance.

In America it is remarkable that the first discovery of this mineral, of which we have any written record, should have been made as far in the interior as Illinois. It is mentioned by Father Hennepin in 1669, when he found the outcrop of a seam on the Illinois River, where the town of Ottawa now stands. The first that came into use, however, was that from Virginia, near Richmond, which for a long time supplied the whole Atlantic market. Anthracite (of which we produced over 21,000,000 tons in 1877) had quite a struggle to obtain a footing, as its value and use were not known ; in fact, the first Lehigh coal sent to Philadelphia in 1803 was considered worthless, and was broken up to be used on the sidewalks.

In the early days of this country, wood was so abundant and cheap, and the means of transportation from the interior so limited, that the demand for fossil fuel in the United States could be met by a few thousand tons a year. We have no accurate record of the tonnage which *was* produced, but it was about 1,600 tons of anthracite and about 80,000 tons of bituminous in 1820, which was one ton to every one hundred and twenty persons of the population. As the country was settled, railroads built, furnaces erected, and steam and machinery came into greater and greater use, the demand increased, until in 1877 the production was one and a quarter ton to every man, woman, and child of the Union—or 50,000,000 tons. The vast quantity represented by these figures can be better brought before the mind by stating that, if this amount were packed in a *solid* mass, it would make a wall from New York to Washington—two hundred and forty miles—ten feet wide and eighty-five feet high; while, if it were put together in the broken state in which coal is commonly used, the wall would be one hundred and sixty-one feet high. This tonnage places our country as the second coal-producer in the world, Great Britain being first, with an output in 1877 of about 130,000,000 tons.

From what has been said regarding the power and wealth that this article bestows, the following table shows that the American Union has a most magnificent future prospect, as it is destined to become the great fuel-producer of the earth ; and that not only because of the vast area of its coal-fields, but because of the thousands of square miles wherein the seams are so easily accessible to the miner; as they often lie either above water-level or at very moderate depths, thus òbviating the expense of deep and costly shafts to reach them, and this is a very great advantage. " So immense indeed are the riches of the American coal-measures that, in their conception of the future development of mankind, geographers, historians, philosophers, agree in the idea that the United States have, especially in their coal-deposits, the elements for the greatest and most perfect development of the human race" (Lesquereux).

COUNTRIES.	Area of Coal-fields in Square Miles.	Percentage of Total Area.
United States	192,000	73.85
Nova Scotia	18,000	6.90
Great Britain	11,900	4.60
Spain	3,000	1.20
France	1,800	0.70
Prussia	1,800	0.70
Austria	1,800	0.70
Belgium	900	0.35
Chili, Australia, India, China, etc.	28,800	11.00
Totals	260,000	100.00

And now for the story of how this wonderful mineral was formed. It is one of the well-established facts of geology that it is of vegetable origin. This is not simply a theory, for in Nature coal can be seen in various stages of formation where vegetable tissue is heaped up and accumulated in bogs. As we dig down into these bogs where the woody matter is surrounded by moisture, and in a favorable position for slow decomposition, it is seen that it is transformed into a dark, combustible compound which is first called *peat*; then, as it becomes harder and more changed, *lignite*; while the oldest peat-bogs in Europe have, at or near their bottom, thin layers of hard, black matter that neither examination by the eye nor analysis by the chemist can distinguish from true coal, and which, therefore, must be true coal. "In Holland, Denmark, and Sweden, the thick deposits of peat are separated into distinct beds by strata of sand and mud, giving the best possible elucidation of the process of stratification of the coal-measures" (Lesquereux). For their formation these bogs require a basin rendered impermeable by a substratum of clay and an active growth of aquatic or semi-aërial plants, having their roots in water, while their branches and leaves expand on the surface thereof, or rise in the air above it, constantly growing in the same place, whose *débris*, falling year after year, is heaped up and preserved against atmospheric decomposition by stagnant water or great humidity in the air. It was during the Carboniferous epoch, when our principal and most valuable seams of coal were deposited, that all these favorable circumstances were in their highest development. For a dense vegetation we also want a warm, moist, and equable climate, and air more or less charged with carbonic-acid gas, as that is the food of plants (just as the oxygen gives life to man), though it is poisonous to warm-blooded animals, it being impossible for such to live in an atmosphere containing more than about one per cent. of it.

During the Carboniferous age of the earth's history the water covered very much more of area than it now does, and portions of the continents were so little raised above its surface that a slight elevation or depression would change them from marshes and lagoons into dry land, or sink them below the surface of the sea. When air passes over, or rests on, oceans, or lakes, or rivers, etc., it becomes laden with vapor,

whose influence is very potent, as its power of absorbing and retaining heat is thousands of times greater than that of air. Hence, as the ocean was so largely preponderant, there was an atmosphere heavily charged with moisture, which in time was favorable to a warm and equable climate. In fact, the want of annual rings in carboniferous plants proves that there was no winter, and, as the same coal-plants grew at the same time in Europe and America, the same climate must have prevailed. The air was also charged with carbonic acid, for there are no fossils (which Prof. Huxley so beautifully says are the labels that an Almighty hand has put upon the specimens in Nature's museum) in this or any other earlier formation of warm-blooded animals.

In all these circumstances, therefore, there exist the most advantageous conditions for the rapid and continuous growth of vegetation, and, judging from the fossils thereof, it must have gone on with a density and luxuriance that wellnigh surpasses conception. Floating vegetables first made their appearance, spreading their branches and leaves on the surface of the water, and filling the basin or lagoon with their *débris*, thus forming a support for the more aërial vegetation, compared with which anything in our day of the same species, in respect to size and quantity, fades into insignificance.

The exuberant growth of the tropics is astonishing to us; but it is as nothing when we contemplate that of the coal era. For example: *Equisetum*, the horse-tail flag, with us is never more than half an inch in diameter, while in the coal-rocks gigantic reeds of this kind were as much as fourteen inches in diameter. Living club-mosses, even in our tropics, attain no great height, but there they were as thick as a man's body and sixty and seventy feet high. Our ferns are of insignificant size, but in those olden days they raised their feathery foliage to a height of sixty feet and upward. There are others that grew to the same wonderful proportions; and as they fell others sprang up, and thus the "heaping" process continued until Nature caused some subsidence of the ground; the water closed over it all, and the currents deposited mud and sand upon it: if the former, a stratum of slate was the ultimate result; if the latter, a stratum of sandstone. When this subsidence ceased, fresh growths sprang up and a new deposit was formed, to sink and be covered in its turn; and as often as these periods of rest and submergence were repeated, so often did a new coal-bed come into existence, and in this is a simple rational explanation why the coal-measures have more than one seam in them.

If, on the other hand, an elevation took place, the roots of the plants were deprived of their moisture, and they not only ceased growing and the deposit accumulating, but the rains and surface-drainage gradually eroded the latter away, and, as it floated off, it became mixed with any earthy matter which the waters may have had in mechanical suspension; and, when it was finally deposited in some lagoon or overspread other formations, it ultimately made an inferior coal, or a black

slate, according to the preponderance of the mud which was with it. Thus we can understand one of the causes why some regions have more seams than others.

When the deposit was covered up, as before explained, a gradual decomposition took place, which consisted in an evolution of a portion of the carbon, and most of the hydrogen and oxygen, in the form of water and gases from the woody tissue, leaving a larger and larger percentage of the carbon of the plant behind, while the increased pressure of the accumulating strata above served to compress and solidify the mass. But before this solidification took place, as Liebig has proved, by direct experiment in the process of slow decomposition of vegetable matter in water, a softening occurred, and it is to this that we must ascribe the fact that no delicate fossils are ever found in the coal itself, as the tissue and form were destroyed by the softening and subsequent pressure, though cases are met with where solid trunks of trees have resisted this softening process, and are found standing erect in the seams while their roots are plainly traced in the clay-slate below. In the slates above and below, which, it must be remembered, were originally soft, plastic mud, the plant-impressions, however, are as sharp and clear as though they had been sketched with an artist's pencil.

The formation of different kinds of coals, such as anthracite, semi-anthracite, semi-bituminous, and the many different varieties of bituminous, is supposed to be owing to the different degrees of progress made in the process of softening and carbonization, and to there having been freer escape for the gaseous constituents in some cases than in others. Chemists have actually converted vegetable matter into coal of all degrees of hardness, and possessing all the various qualities of that formed by Nature, and observation and their labors seem to show that all coal was first formed of the bituminous variety, and that anthracite is the result of igneous action to which it was subsequently subjected (MacFarlane). When this change has been carried still further, the result is plumbago, or black-lead.

I have thus endeavored to set forth in a plain, comprehensible manner the theories of the formation of our fossil fuels, and, while difficulties may suggest themselves to the reader, still that they are derived from the vegetable kingdom admits of no doubt, this being one of the well-established facts of geology.

There is one more benefit that coal has been the cause of bestowing upon mankind that is as striking as all those previously set forth, to which I would call attention before closing. The Bible tells us that the beasts of the field and the fowls of the air were not created until after the earth brought forth grass, the herb yielding seed, and the fruit-tree yielding fruit after his kind; and with the aid of science we can see a reason for this. It has been stated that one of the requisites for the vegetation of the coal era to flourish as it did was that the atmosphere should be charged with a compound of carbon and oxygen known as

carbonic-acid gas, and that this gas, except in very small proportion, destroys life in warm-blooded animals. It was the tree that drank in the noxious vapor through its leaves, decomposed it, took of the carbon to add to its stature, and to yield seed and fruit after its kind, while it breathed the life-producing oxygen back into the air, and in this way the atmosphere was purified for the use of man and beast.

Thus in the economy and wonderful working of Nature not only was this gas, that precluded life, removed, but it was stored up for the future use of that same life that its removal made possible, so that coal, besides giving light and warmth, and a thousand other material blessings, was the prime cause of the very air we breathe. Surely it is, and it has been, a wonderful and blessed boon to the earth and its population, and it is of no wonder that it has been given the name of the most costly gem we know when it is called black " diamond."

THE DEVIL-FISH AND ITS RELATIVES.[1]

By W. E. DAMON.

PERHAPS no better introduction to this chapter can be given than to recall to the minds of our readers the terribly vivid description of the devil-fish by that grand master of romance, Victor Hugo; for, though incorrect in several scientific details, the general description is the best we have had, though Jules Verne's is almost as dramatic and nearer to Nature. In "Les Travailleurs de la Mer" M. Hugo says: "To believe in the existence of the devil-fish, one must have seen it. Compared to it the ancient hydras were insignificant. Orpheus, Homer, and Hesiod, *imagined* only the chimæra—Providence *created* the octopus. If terror was the object of its creation, it is perfection. The devil-fish has no muscular organization, no menacing cry, no breastplate, no horn, no dart, no tail with which to hold or bruise, no cutting fins, or wings with claws, no prickles, no sword, no electric discharge, no venom, no talons, no beak (?), no teeth. It has no bones, no blood, no flesh. It is soft and flabby, . . . a skin with nothing inside of it. Its under surface is yellowish; its upper earthy. Its dusty hue can neither be imitated nor explained; it might be called a beast made of ashes which inhabits the water. Irritated, it becomes violet. It is a spider in form, a chameleon in coloration.

"Seized by this animal," he adds, "you enter into the beast; the hydra incorporates itself with the man; the man is amalgamated with the hydra. You become one. The tiger can only devour you; the devil-fish *inhales* you. He draws you *to* him, *into* him; and, bound and

[1] From "Ocean Wonders," in the press of D. Appleton & Co.

helpless, you feel yourself slowly emptied into this frightful sac, which is a monster. To be eaten alive is more than terrible; but to be *drunk* alive is inexpressible!"

This overwrought but wonderfully dramatic description (but a small part of which we have quoted) at once excited a popular interest in the habits and history of the octopus, though it was well known and described by Aristotle before the Christian era. Moreover, the animal so

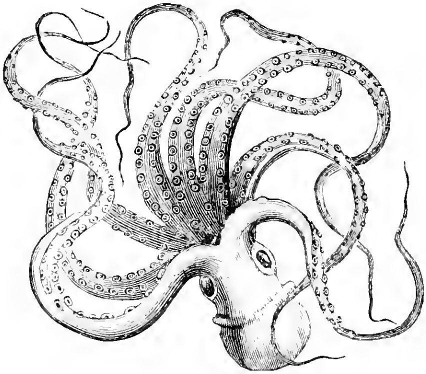


FIG 1.—OCTOPUS OR DEVIL-FISH (*Octopus vulgaris*).

graphically pictured by the novelist was a mere "baby devil" in comparison with many which exist, and which have been described by that enthusiastic naturalist, Prof. Verrill, of Yale College.

In a letter addressed to me on this subject by Prof. Spencer F. Baird, under date of April 1, 1878, this distinguished naturalist says: "The giant squid in the New York Aquarium can only be designated as an infant or dwarf in comparison with the gigantic species of the Pacific Ocean—those upon which the sperm-whale is known to feed. Chunks of squid-remains are not infrequently found in the throat or stomach of the sperm-whale, apparently indicating specimens from ten to fifty times the size of the Newfoundland variety. I was informed that a considerably larger specimen than that at New York was cast ashore at Newfoundland later in the season. The arms of the latter, if I recollect right, were some ten feet longer than those of the other."

The specimen referred to by Prof. Baird, as at the public aquarium in New York, is of the species known as *Architeuthis princeps.* It measures about forty feet, and is preserved in alcohol. I have in a bottle some specimen portions of the sucking-disks, showing the serrated edges, from the arms of this terrible animal; and I have also a perfect specimen of a smaller species of the animal itself in my private collection.

Prof. Verrill's reports apply to the devil-fish found in our northern seas, and Prof. Baird mentions those cast ashore at Newfoundland; but

that they are not limited to the northern waters is certain. The late Captain Frederick Reimer, of New Jersey, a very intelligent observer, who was in Beaufort Harbor, North Carolina, in 1862, described one that he saw there which measured fully thirty feet in length. Any one who has seen the specimen captured at Newfoundland can readily conceive how such a monster could stretch out its two long arms and seize its prey. These arms together form a pair of powerful pincers at their extreme ends, and are furnished for their whole length with two rows of

FIG. 2.—THE GIANT SQUID.

perfect sucking-disks, or some two thousand air-pumps; the edges are also cut into sharp, saw-like teeth, as hard as steel, and these are buried in the flesh of its prey. With all these appliances it could easily reach a distance of twenty-five feet, and bring the body of a man to its mouth,

where, with its powerful iron-like beak, it crushes the helpless form, and swallows or *drinks* it down, as Victor Hugo says.

My own experience with these creatures has been principally in the Bermudas. They are there caught in basket-traps, formed of wood. With a trap baited with mussel, crab, or lobster, of which the octopus is particularly fond, we row along the island-shore, among the more rocky parts, until we discover some indication of the animal's retreat. Their hiding-places can only be discovered by experts, but one of the trails by which they are traced is the presence of dead shells in unusual quantities, particularly skeletons of crabs, which will be pretty certainly seen near the water's edge, or at the mouth of the cave inhabited by a "devil." The clearness of the waters greatly aids in the search. When a promising location is reached, we throw overboard the trap, which sinks to the bottom of some ledge, or rests upon a reef of coral. A rope, which is attached to it, is secured to a buoy to mark its place on the surface of the sea, and it is left for twenty-four hours. Then we return and haul it up, and, if the place of deposit has been well chosen, we shall soon see the long arms of Mr. Devil protruding through the basket, searching and stretching in all directions, seeking to understand how it is that positions have become so reversed—that he is the captured instead of the capturing party. His color changes with anger and vexation, and his body then displays numerous bunches or tubercles, which always appear when the animal anticipates danger.

The trap being opened, we seize him quickly by what we must call neck, the portion between the head and trunk, while his eight arms or legs, as you may choose to call them, are struggling and twisting in all directions, sometimes becoming attached to our own arms and twin-

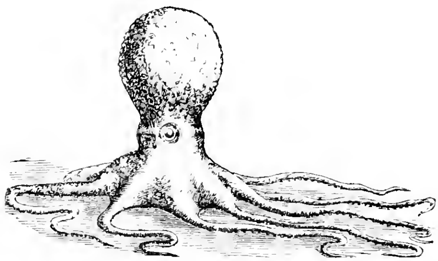


FIG. 3.—AN OCTOPUS RUNNING.

ing about them. Those which I caught and handled had arms of remarkable softness and suppleness, so that their contact felt more like a running liquid upon my flesh than a structural substance;[1] and, indeed, though so formidable under certain circumstances, the preponderance of fluidity in their composition may be judged from the fact that I my-

[1] This lack of tension probably resulted from my pressure upon the neck.

self saw one, which measured three feet in length by five or six inches in width, sqeeze or *run* itself through a crevice not over *half an inch* in width!

I should have mentioned that if it is desired to preserve the octopus alive, the pressure on the neck should not be too severe, for that is their vulnerable point; and a person attacked by one should never lose time in striving to loosen its arms, but grasp if possible this portion connecting the head and body, in which way they may be easily killed.

In regard to their powers of locomotion upon land, on which there has been considerable controversy, I can assure the reader that I have seen a full-grown octopus at the Bermudas spring up out of the water, only a few feet forward of the boat I was in, and run up a perpendicular rocky cliff for more than *two hundred feet!* This ledge of rock bore a general resemblance to our Hudson River Palisades at their steepest portion. We soon learned the cause of this seemingly strange performance, when we discovered one of those beautiful bright-red crabs, which are native to the locality, trying to escape from the clutches of this devil-fish. The crab, being frightened almost out of its simple wits, had run up the rocks for safety; but its tactics proved sure death in the end. As to the speed of the octopus, it appeared to me to travel much faster than I could run. At least, I should not care, if unarmed, to engage in a race with one, unless Mr. Devil started a good way *ahead.*

In this case I soon came into closer acquaintance with our agile friend, for the next morning I had the satisfaction of discovering that he had walked into our trap, which we had carefully placed near his cave; and now that we could see him face to face, we found that his strength was enormous as compared with his moderate size. Being placed in a bucket of water, such as is usually found on a ship's deck, he attached his eight arms to the bottom and sides, by means of his powerful and perfect-working suction-disks, so firmly, that I several times lifted the bucket, water and all, by taking hold of the animal's body, and twirled it over my head. The more I twirled the more firmly it stuck. An octopus will not relax its hold "on compulsion," any more than Falstaff would "give reasons." It is as self-willed as some human animals.

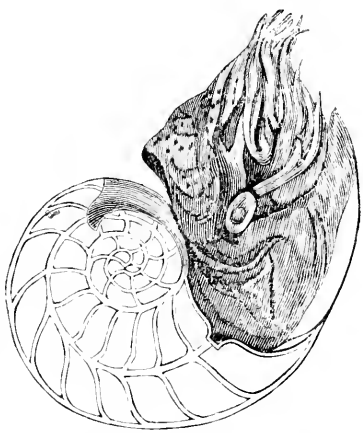


FIG. 4.—PEARLY NAUTILUS (*Nautilus pompilius*), showing chambers inside of shell.

According to scientific classification, the octopus belongs to the division of soft-bodied *Mollusca*, and the class of *Cephalopoda*—mean-

ing "feet proceeding from the head." Of these the octopus, as its name indicates, has eight feet, or arms; for, though these long appendages are sometimes used as feet, they are habitually used as arms.

Of the octopoda family is the small paper nautilus or argonaut. How few of our readers who have admired this beautiful shell, with its mother-of-pearl lining, have realized that its former inhabitant was own cousin to the horrible devil-fish!—a female cousin, we must add, for the shell is not connected with the animal organically, but is held in position by two of the long arms, with the sole purpose of protecting the eggs. The male argonaut has no shell.

Though all the octopods, large or small, can swim freely at will, such is not their habit; they prefer to lie concealed, or partially so, on

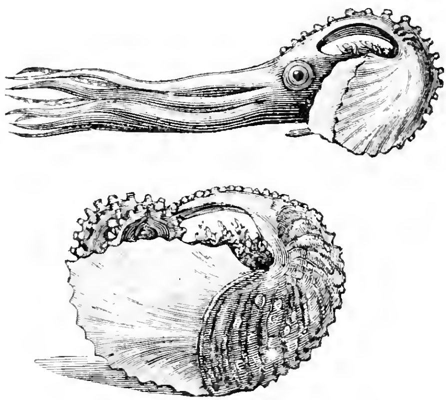


FIG. 5.—PAPER NAUTILUS (*Argonauta argo*).

the side or in the clefts of rocks. There the octopod's body is protected from the attacks of other animals, while it can extend its long feelers in search of prey, of which fish, mollusks, and crustaceans, are the principal objects. Its movements, when an object of food is perceived, are marvelously rapid, swifter than the flight of an arrow from the bow of an experienced hunter. The long, flexible arms grasp the victim; its hundreds of suckers, acting like pneumatic holders, make escape impossible; and, as the long arms draw the object nearer and nearer, the other shorter arms add their multiplied disks, forming "a perfect mitrailleuse of inverted air-guns, which take horrid hold, and the pressure of air is so great that nothing but closing the throttle-valve can produce relaxation." This throttle-valve is the neck, as we have before described. Those lengthy appendages, the limbs, are rather in the way when the animal is swimming, and would act as drag-anchors if left pendent; but the octopus usually draws them close alongside, whence they extend in an horizontal position, acting the part of a tail to a kite. It propels itself by drawing in and expelling water through its locomotory tube.

The octopus swims backward, and it has been remarked that it changes its color to a darker hue when it starts out for a swim.

This change of hue, apparently at will, is one of the most peculiar characteristics of the octopus. It may be considered the chameleon of the sea. Its ordinary color when in repose is a mottled brown; but if irritated it assumes a reddish hue, approaching to purple. Nature seems to have been almost superfluously careful in furnishing this animal with protecting elements; for this coloring-matter, which resides between the inner and outer skin, enables it even to assume the color of the ground or rocks over which it travels, so that one can hardly say what color it is before it may have changed to something quite different. When exhausted after a battle or a struggle to get out of a trap, it turns pale, like a human being.

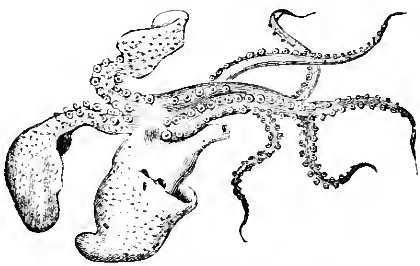


FIG. 6.—ARGONAUT WITHOUT THE SHELL.

Others besides Victor Hugo's hero have had a chance to test the strength of these devil-fishes. Major Newsome, R. E., when stationed on the east coast of Africa in 1856–'57, undertook to bathe in a pool of water left by the retiring waves. He says: "As I swam from one end to the other, I was horrified at feeling something around my ankle, and made for the side as speedily as I could. I thought at first it was only sea-weed; but as I landed and trod with my foot on the rock, my disgust was heightened at feeling a fleshy and slippery substance under me. I was, I confess, alarmed; and so apparently was the beast on which I trod, for he detached himself and made for the water. Some fellow-bathers came to my assistance, and he was eventually landed. . . . As the grasp of an ordinary-sized octopus holding to a rock is not less than thirty pounds, while the floating power of a man is between five and six pounds, I believe if I had not kept in mid-channel it would have been a life-and-death struggle between myself and the beast on my ankle. In the open water I was the best man; but near the bottom or sides, which he could have reached with his arms, but which I could not have reached with mine, he would certainly have drowned me."

The major was right; he had every chance of sharing the fate of the immortal Clubin.

When a crustacean casts a limb from its junction with the body, it is after a time reproduced; if injured below this point, it has no recuperative power. But our "devil-fish," which really seems favored beyond its deserts, will reproduce any injured portion of its arms, at whatever point they may have been severed; of the numerous specimens which have been scientifically examined, many showed that one, two, or more arms have been either repaired or reproduced; and some of the female specimens have shown a loss of the whole eight arms, but all more or less restored.

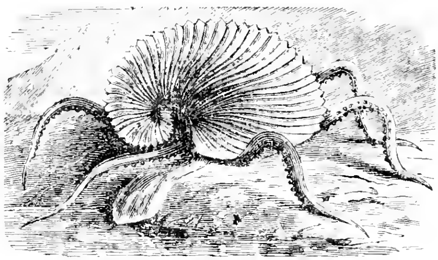


Fig. 7.—Argonaut with the Shell.

Another kind of exuviæ observed with the octopods is the outer skin of their long limbs, which they not infrequently shed. These cast-off skins float upon the water, and are one of the indications which lead to the discovery of their retreats. When the outer skin becomes too tight for the growing animal, or is worn too smooth by frequent contact with the rocks, the creature may be seen rubbing its arms against each other as if they were undergoing a scrubbing or cleansing process, and soon these thin, filmy skins may be seen floating away on the surface of the water.

At certain periods there appears in the male octopus what is called the *hectocotylus* development in one of the arms. When this gentleman would a-wooing go, as Mr. Lee says in his valuable little book on this subject, and "he offers his hand in marriage to a lady octopus, she accepts it most literally, *keeps it, and walks away with it*; for this singular outgrowth is detached from the arm of the suitor, and becomes a separate living creature," specimens of which have been preserved in the Museum of Natural History in Paris. This *hectocotylized* arm is afterward reproduced in the male.

It is surprising with what care the female watches over the development of the eggs. Having selected a snug retreat in the rocks, she will barricade it by dragging to the entrance other portions of rock, or perhaps a pile of oysters—anything out of which she can make a strong breastwork or line of defense; and then she sits on guard ready to attack any intruder, even though it be her own mate. The eggs when first laid are about the size of grains of rice, and are arranged upon a

stalk which is attached to the rock by a cement secreted by the parent, and to which each egg is separately attached, like a mass of bananas on its stalk, only much more closely packed, the number being immense; an octopus will produce in one laying from forty to fifty thousand. Mr. Lee describes one that he had under observation in an aquarium, which he says "would pass one of her arms beneath the hanging bunches of her eggs, and, dilating the membrane on each side of it into a boat-shaped hollow, would gather and hold them in, as in a trough or cradle. Then she would caress and gently rub them, occasionally turning toward them the mouth of her flexible exhalent and locomotor tube, which resembles the nozzle of a hose-pipe, and direct upon them a jet of water." The object of the syringing process was probably to free the eggs from parasites, or to prevent the growth of confervæ upon them. At the end of five weeks some of the eggs were taken from the nest for observation under the microscope, which showed that the young octopods were already alive and freely swimming within the shell; and most extraordinary was it to see that these immature creatures exhibited the characteristic changes of color at that early

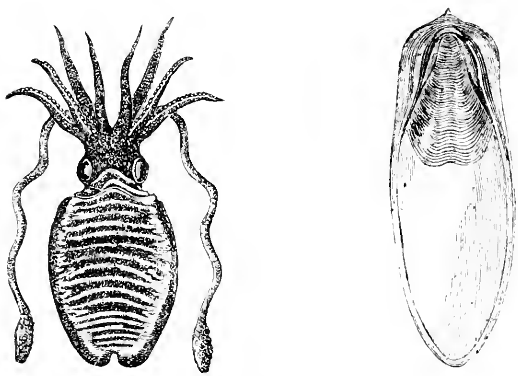


FIG. 8.—SEPIA OFFICINALIS AND SHELL.

stage of development, flushing red apparently with anger when disturbed. The period of incubation is about fifty days, and during all that time the mother octopus brooded her eggs with the tenderest care; so that the observer almost ceased to look upon her in the light of a "devil-fish," and recognized that at least the maternal instinct was not dependent for its development upon external beauty.

When the young octopus emerges from the egg it is about the size of a large flea, but has none of the arms developed; these appear simply as "rudimentary conical excrescences, having points of hair-like fineness arranged in the form of an eight-rayed coronet upon the head." The amiable disposition of all female devil-fish is not perhaps equal to that of the one described above; but it is not an unusual event for

them to die from the effects of exhaustion at the end of the long brooding period. This may perhaps partly result from insufficient nourishment, as they must evidently miss many chances of obtaining food, which others, unburdened with family cares, avail themselves of.

The nearest relations of the octopus are the cuttle-fish and squids. The former, *Sepia officinalis*, is best known as the animal which produces that fine black-coloring fluid known as sepia-ink, and for its useful *sepiostaire* or internal shell, which is usually hung in the cages of canary-birds.

Though the cuttle-fish resembles in its general structure its relative the octopus, it varies in several particulars. Instead of eight arms, it has ten, eight short and two long. Some persons have pronounced them "beautiful"—in which opinion we cannot coincide; but their manners are decidedly more genial than those of the octopus. Instead of lurking in semi-concealed caves or behind rocks, and springing upon the unwary like a tiger from its jungle, the cuttle-fish comes out to the light and gives his intended victim a fair chance, having more the habits of a bird of prey than its congener the devil-fish. It is, however, very voracious, and fishermen have often cause to regret its proximity to the fishing-grounds, as it will attack fish while entangled in the nets and drag them out or bite and mutilate them. When attacked, its best defense is the sepia-bag, from which it ejects the black fluid, thus discoloring the water and escaping in the obscurity.

The eggs of the cuttle-fish are usually found attached to a branch of sea-weed and very ingeniously hung by a perfect loop, each one separately upon the twig, where together they somewhat resemble a bunch of grapes. As soon as the young are released, they seek the light and approach the surface of the water. The sepia is naturally very shy, and at the slightest alarm shoots forth with wonderful rapidity its foe-defying ink; but in captivity its fears may be overcome by kindness. It is not difficult to tame, and in time it appears to recognize and appreciate its protector, ceasing to discolor the water when sufficient familiarity has been established between them.

The eyes of the cuttle are so solid as to be almost calcareous, and are divided by a groove in the centre; these halves are nearly globose at their outer surfaces, and reflect light with a "beautiful nacreous opalescence and play of colors." In Italy they are made into beads for necklaces. The cuttle-bone when pounded is used as a polishing powder by jewelers, under the name of "pounce." It is also manufactured into a dentifrice, and sold under the name of "white coral-powder." Artists still use the natural *sepia* to some extent.

The *common squid* (*Loligo vulgaris*) has the same number of arms as the cuttle, but differs in form and some other particulars. The body of the cuttle is of a broad oval shape, with no perceptible neck; the squid is nearly triangular in shape, and has two plainly defined necks, one much smaller inserted within the other and projecting beyond it.

It has also very large eyes in proportion to its size. It is a free swimmer like the cuttle; its spawn is also left to float freely, but in a large circular mass, consisting of an immense number of branches, all containing quantities of ova and united to a common centre. It has been estimated that these "mop-like" masses contain nearly forty thousand eggs. The squid is also privileged to carry an ink-bag, of which he makes very free use; and many fishermen attempting to catch them have experienced the fate of Tom Hood, of whom Mr. Lee tells the anecdote that, being unaware of this propensity of the cuttle-fish and squid, and having caught one of the former on his hook while angling in Love Harbor, he laid hold of it to unhook it, and received its full *jet d'eau* in the face. On being asked what he had on his line, he replied that he did not know exactly, but he thought *he had caught a young garden engine!*

As these sorts of creatures are never eaten in this country, it may be news to some that they are very extensively used as food in many countries at the present time, and that the ancient as well as the modern Greeks considered them a delicacy when properly cooked. One cause of the favor in which they are held by the Orthodox Greek Catholics on the shores of the Ægean Sea is the substitute which they offer in place of meat and fish, both of which are forbidden during the long fasts of the Greek Church. A cuttle is practically declared not to be a fish, and certainly it is not meat; and so it finds its way into the pots and frying-pans even of the ecclesiastics during Lent and other fasts in great quantities. A common way of catching them in the Mediterranean is by planting traps of stone jars or earthenware tubes, into which they creep, and are thus drawn up and secured. Everywhere they are used for bait, and the Indians of Vancouver's Island and Alaska eat them with relish, as do the inhabitants of China and the western coast of South America. There is a good story told of a party of *savants* in England endeavoring to make a dish of one, at a special dinner given for the purpose; but the attempt was a complete failure—no one could swallow a morsel. The ancients described them under the name of *polypus*, and all classical scholars will recall the frequent references to these animals as articles of diet, especially by the comic poets.

The greatest enemies to the class of cephalopods are the porpoises, dolphins, and conger-eels. The last do not hesitate to attack even a devil-fish of considerable size, while the young are snapped up by a great variety of fishes. In fact, if the great mass of all the spawn produced by the denizens of the ocean were not devoured or otherwise destroyed, the watery world would long ago have become so over-populated as to be unnavigable, and its condition incompatible with the health of the human race.

HEREDITY.

By GEORGE ILES.

HAWTHORNE in his masterpiece, the "Scarlet Letter," makes his heroine, Hester Prynne, a woman who has sinned, resolutely refuse to tell the name of her partner in guilt when the Puritan inquisitors urge her to do so. The ministers of justice and vengeance then turn to her child, and sharply scrutinize her features, to find if possible some trace of her father's look, that the wrong done may be punished. Here, too, they are unsuccessful—the face of the little elf tells no story that they can read, gives them no clew in their task of detection; they are obliged to withdraw, baffled and surly. This incident in the greatest of American romances is true to experience; while the inheritance from parents of form and character is general, yet it is not universal, and while some of the exceptions, when explained, afford very interesting studies of the play of natural forces, too subtile to be noticed by simple inspection of their results, yet many anomalies exist in heredity which the science of to-day is quite incompetent to explain.

The inheritance of the peculiarities of physical structure is a matter of daily and hourly observation, and the minute fidelity of it is at times very remarkable. Agassiz placed on record cases where traces of surgical operations had been transmitted. Sometimes parent and child are not only alike in form and feature, but even in tricks of tone and gesture, handwriting and gait.

The predisposition to certain diseases, like gout or insanity, often developed after maturity, is transmissible; and also the liability to die about a certain age. The famous Turgots, for more than a century, rarely exceeded fifty years of age; and insanity often appears after the meridian of life in several successive generations of a family. The remarkable faithfulness of reproduction in the majority of cases is a fact somewhat parallel to the growth and maintenance of an organism, wherein, with the constant succession of cells each of brief existence, substantial identity is kept up. There do not seem to be very marked differences in babes, yet from the same food one will become a man of muscle and energy, another of nerve and brain, a third a portly man of ease-loving habits. All the original peculiarities of each tiny human nucleus pick out from a common nourishment elements like themselves, rejecting the rest.

Inheritance is not only physical, but intellectual as well; great ability in mathematics, painting, music, and other departments of effort, has clearly been received at birth in many thousands of examples. The Bach family for two hundred years maintained exalted rank in music. The direct succession of very able men in the families of

Pitt, Napier, Fox, Herschel, Darwin, and many more, is evidence that mind and will are as transmissible as complexion and stature. This is more apparent in a country like England, where the institutions and customs favor and confirm the results of heredity, than in America, where there is no law of entail, and as yet little of the ambitious founding of families.

There is abundant testimony to prove that heredity can be moral as well as physical and intellectual. The Stuarts were as constant in the presentation of certain moral traits as the family of the Churchills or the American Adamses are in others. Imprudence, penuriousness, dishonesty, or good judgment, once thoroughly established in a stock, persists with quite as much tenacity as the familiar eyes or nose. The inheritance by posterity of the changes wrought on individuals by their experience is the basis of the modern explanation of the growth of instinct and the evolution of human intelligence. Darwin has developed this theory in a masterly manner. He gives as an illustration that between the finished skill of the honey-bee and the rude capabilities of the humble-bee stand the intermediate powers of the Mexican melipona. This last insect constructs a comb of wax, almost regular in form, consisting of cylindrical cells, in which the larvæ are hatched, and a certain number of large cells to hold its store of honey. The latter cells are nearly spherical and situated at a considerable distance from each other. Now, any slight variation of organization or instinct, by which the melipona would construct its cells more uniformly and compactly, would economize its wax and labor, and bring it up toward the plane of the honey-bee. The generations of insects succeed each other so rapidly that no modification can be detected among species low in the scale. Honey-bees, however, are not possessed of unadaptable and rigid instincts, for they have been observed to spring arches and buttresses in their hives to avoid glass rods purposely inserted. An organism's advantage plainly lies in an increase of its skill and ingenuity, and any slight advance made by individuals is preserved by heredity, persists in tendencies and habit, and becomes fixed as instinct.

The development of intelligence among mankind is accounted for in the same manner : efforts at first painfully made by our ancestors in new paths were at last rewarded by the facility that comes with repetition ; their immediate descendants were born with new aptitudes and an organization with a wider range of powers ; the acquisitions thus gained and transmitted have grown into the varied faculties of the men and women of to-day. "Mankind," Comte says, "is as one man, always living and always learning." The passing away of one generation and the birth of another do not interfere with the constant progress of the race.

The method applied to the explication of the growth of instinct and intelligence has been used by Darwin in approaching the problem

of the origin of the conscience from the side of natural history. He deems it to have had its beginning when an animal could contrast the transient pleasure given by the gratification of a passion with the abiding pain afterward felt. An enlargement of memory must have come before the immediate and remote effects of actions could be compared in consciousness, and the greater good recognized and chosen.

This theory of conscience, which holds it to have been created by the experiences of the race confirming habits best suited for social life, well accords with the theory of morals which takes benefit or utility, in its largest sense, as the test and sanction of right conduct.

While the manifestations of heredity in their obvious effects are interesting, yet the laws brought to light by an examination of some results apparently exceptional and contradictory are of still deeper interest. A single great law may underlie a large group of problems, yet many other principles of minor weight may coöperate with it and obscure its direct force. The study of residual phenomena is ever fraught with increased knowledge and the unfailing testimony that where law seems to be at fault it is only so from our ignorance of the varied energies at work, which are constantly revealed to the patient searcher for truth. In the science of heredity many apparent anomalies have been resolved in allowing for the action of forces newly discovered or applied.

The study of the unconscious powers of the mind has of late years attracted much attention ; observation has found that there may lie latent in a man tendencies and forces whose existence he may never suspect, but which he is capable of transmitting to children who shall palpably develop them. Insanity, gout, and melancholia, frequently skip a generation and reappear when hopes have been entertained that the evil trait had died out in the family. A son may resemble his mother very markedly, and have children with the features and character of his father. The evidence of heredity is thus borne out frequently in the long-run, when to a contracted view it would seem at fault. An individual inherits not only from his parents but from all their predecessors in the line of life, and just what of them shall appear evidently in him, and what be hidden in unconsciousness, none can tell. The surface forces of the man may be like the momentum of a tree falling down a mountain-slope, but the inner and dormant powers never to be manifested during a lifetime may as far transcend the energies actually shown as the force of the fire which the tree may feed excels that of its mere bodily impact in descent.

The dormancy of traits accounts for atavism or the reversion of an organism to the form and character of ancestral stock. Pigeons, dogs, and horses, frequently relapse, so to speak, to the inferior type from which they have been bred, and so exhibit a wide divergence from their immediate parents. Reversion of this kind has been noticed in the silkworm after a hundred generations. So long in Nature does an

organism retain substantially the same form, that when art produces a rapid modification of structure, or desires to seize upon a valuable and marked variety, repeated and careful selection is required to give it permanence.

The principle of atavism explains the curious resemblance often seen in a human family between uncle and nephew; the likeness in such cases is derived from some common ancestor, the grandfather most usually.

Mr. Galton, in his work on "Hereditary Genius," adopts the statistical method to prove that illustrious men arise oftenest from families displaying eminent talent, and have relatives approaching to themselves in ability in a degree proportioned to the nearness of kinship. A man of genius is much more likely to have a remarkable father or son, than a nephew or cousin. Great men, Galton says, seem to arise like islands, isolated and unaccountable; but this is an illusion—they are given to us usually by parents unknown from the necessarily narrow limitations of fame; islands are but the tops of hills whose whole extent is hidden by obscuring ocean. Yet the exceptions to this rule are very numerous: why should Cromwell, Milton, Goethe, and so many others, leave behind them unworthy children? Was it from unfortunate mating with an inferior mother, or because the vitality, physical and mental, was too much drawn upon by the individual life for worthy continuation? How can it be explained that men like Burns and Faraday should come up from families in which even enthusiastic biographers can find nothing to distinguish them from their neighbors?

The wide unlikeness frequently observed between parents and children in talent and character suggests an analogy with a familiar fact in chemistry. A compound's color, weight, and other properties, may be changed almost beyond recognition by adding or eliminating a single element. It is somewhat so in human nature; a father of warm passions or strong acquisitive impulses may transmit all his traits to a son, except prudence; and the omission may cause much sympathy for a reputable and worthy man's being afflicted with a boy so unlike himself. If the lack in inheritance be in perseverance and application, of what value are splendid talents without them?

A lens externally not to be distinguished from a perfect one may, from some slight defect in composition or handling, give images blurred and distorted, instead of true and beautiful. A chain is no stronger than its weakest link, and a small lack or discordance in the elements of character may exclude it from the exacting demands of high place. We often hear regrets that men of genius so rarely have living descendants, but we must not overrate the persistence of ordinary families: taking the first eleven names of acquaintances that occurred to me, I found that three of them were in a fair way of being the last of their race; every old person can recollect the dying out of many once numerous families.

Ribot, the French authority on heredity, alleges two causes as among the chief at work in cases where the law of transmission does not obviously manifest itself. The first is the disproportion of an initiatory force to the amount of energy it may liberate or direct, as in the slight agencies by which fires are lit or explosions set off. The accidental surroundings of a mother before the birth of her child may affect it for life in a way altogether disproportioned to the forces at work. The military excitements in which Madame Bonaparte lived just prior to Napoleon's birth are well known. Anxiety, grief, elation, an unusual degree of physical health or debility at such times are productive of very striking effects, quite capable of masking the likeness between parent and child in form and disposition. The Greeks believed so strongly in the potency of prenatal conditions that they not only guarded mothers who were bearing with the kindest care, but used even to surround them with beautiful works of art, that imagination might act a favorable part.

The second cause which Ribot thinks often tends to obscure the evidence of heredity is the transformation in development of characteristics which are the same at root. Thus a consumptive father has a son who suffers from rheumatism or paralysis. Here the transmission has simply been that of a feeble constitution, which gives way in the first circumstances of severe trial—those favoring rheumatism, paralysis, or other disease. The crystal of life, to use Galton's figure, is disturbed, and reposes on a new facet. In cases where talent appears conspicuously in a family, it may be that energy and patience, productive of but ordinary results in a father, are directed by his son to supplying some new public want, or filling a position created by some sudden national emergency. The constructive powers of Stephenson were less remarkable than his dogged perseverance; and when the world needed steam locomotion he was the man to give it, and surmount the immense difficulties in the way. His strong will is not a rare trait of character, but, joined to his ingenuity, it won him success in his great opportunity. Had Charles I. been a good king, Cromwell would probably have died a brewer. Unbending will was also his chief characteristic, but at Huntingdon it could have enjoyed but narrow play.

Readers of the MONTHLY may remember Galton's paper on "Twins," published in January, 1876. In that paper, based on wide and carefully-made comparisons, it was proved that in the production of character original constitution is a much more important factor than either education or surroundings. The resemblance of twins when it occurs, as it frequently does very strongly, continues through life in a large proportion of cases. The same author has confirmed his opinion that Nature is more powerful than nurture in moulding men, by collecting elaborate testimony from all the illustrious Englishmen of science now living, who say for the most part that their tastes were either innate or manifested themselves very early under the influence of training, and in

some few cases were developed in antagonism to a particular kind of education imparted to them.

Galton thinks that the natural differences among men are far wider than commonly supposed: from a careful study of the statistics of Cambridge examinations, he estimates that the capacity in mathematics of a senior wrangler is to the lowest in the scale of students taking honors as three hundred to one. Similar results have been arrived at by comparisons made in other branches of learning. From all this, it would seem that the popular mind not only underrates the natural differences of men, but also exaggerates the real limits of the improvability of the masses of mankind. Education can only call out one's powers, not bestow them where they are lacking; and supreme minds almost seem to be independent of education, or, at least, always able to get all they need. The task of diffusing information is comparatively an easy one, but the absorption and vitalization of it in the receiving minds is a matter quite beyond the teacher's skill. While we should not expect too much from instruction, we may rightly expect a great deal if it be wisely given; and here it may be fitting to draw attention to a danger in our modern schemes of education, very ably pointed out by Johnson in his recent work on China. The increasing uniformity in methods of instruction, while it may tend to the adoption of the one best plan for an average scholar, has a disadvantage in repressing individuality, and abolishing the many special kinds of teaching for which some teachers are peculiarly fit, and by which some of the best kinds of scholars, different from the average, are notably benefited. The narrow line of a great circle is undoubtedly the shortest path for a ship to take, but, if we would explore new seas and find new truths, the sharply-defined curve of economic navigation must be departed from; and the more diverse the tracks of the ship-master, the more of the deep waters of the unknown will he map out for us.

Instructors sometimes err in being too early in their work, as well as too uniform in their methods; so that matters of great moment lose the bloom of novelty before the reason needed to grasp them matures. One of the compensations for an education coming late in life by one's own effort or otherwise is, that the wonderfulness and suggestiveness of truths come to the mind undampened by any early and useless familiarity.

In the cause of education it is to be regretted that men of the greatest natural endowments can so rarely describe their processes of thought, or analyze their methods of arriving at results. The intuitive perceptions derived from inheritance or long personal experience are of coalescent quality, and are of too rapid awakening to be capable of explanation and record in consciousness. The most original thinkers are, therefore, seldom gifted with the teaching-talent; just as orators and statesmen are not often eminent as authorities in elocution or political economy. Few of the ways and means of intellectual acumen can

be reduced to rule and definitely expressed, yet the error is perennial of regarding logic as reason, and calculations, necessarily imperfect from the extent and complexity of the forces at work, as sound judgment.

The modern view that human intelligence is due to the experiences of the race organized in the brain gives an explanation to a very interesting group of facts. When the education of an individual is totally unlike that received by his line of progenitors, it cannot take deep root in his nature. Every conscientious Christian missionary laments the difficulty of making a really deep impression on a pagan mind. The momentum of ages cannot be changed in direction in a single life, and, if it could, the pledges of human progress, which after all are based on human permanence, would be done away. In the conflict between inherited instincts and personally-acquired convictions, it is as if the man were attempting to fight all his ancestry at once, and he is usually worsted in the fray. Natural historians are familiar with the survival in animals of habits once useful to them in the distant past, but in their changed conditions no longer so. Some reptiles now living on land possess the remnants of organs once used in their perfection by their remote ancestry in aquatic life. In a somewhat parallel way, the superstitions of our progenitors persist in many persons of undoubted common-sense. Madame de Staël said, when asked if she believed in ghosts, "No, but I am afraid of them." When we consider the great problems of life and death in hours of calm reason, our reflections are apt to take a direction very different from that along which our instinctive feelings may impel us in seasons of pain and distress. It is a poor apology for a crude theological belief that our instincts declare it to be true, however much reason may contradict it. Instinct has no infallibility: in the human mind it is simply the register of thoughts and experiences during the long, primitive ages of our race; and our own opinions formed by personal accumulation since birth more probably point toward truth, than the lines of feeling laid down in our fibres in times of struggling intelligence and fierce strifes with natural powers, awful and unknown. In the conflict between instinct and reason, it would be strange indeed to contemn that reason which is only a better instinct than we have now, in the making. The study of race-impulses in an individual makes clear why it is that a man will do generous, heroic deeds, from which it is impossible for him to derive advantage. He acts as he does not from calculation, but from instinctive incitements inherited from parentage of noble blood; the line of race-benefit may not always coincide with that of individual good, but the impetus of ancestral forces transcends self-regard, and leaves the account of debit and credit apparently unbalanced. Not only are human instincts at times noble and heroic, but also, unfortunately more often, cruel and destructive. When a war breaks out, or any great public dissension arises, how speedily can the thin plating of civilization be abraded

away, exposing the old barbarism of the under-nature! The sanguinary and destructive instincts of a people, once thoroughly let loose, can overturn in a few days a social fabric painfully wrought by generations. Of popular outbreaks of fury history has many terrible records, and none more so than of those revolts against order which, as in the French Revolution, had a core of justice in them. The natural differences among men in ability are very marked; much less so are their different capabilities of enjoying the rewards of skill and power: hence inevitably arise discontent and the ignoble spirit of envy; any artificial increase of the gulfs drawn by Nature between one man and another excites this discontent and envy by a conviction of injustice, and endangers order. From these causes the artificial enrichment of nobles and clergy by exemption from taxation has again and again deluged Europe with blood; and the enormous accumulations of property in private hands by bequest and increment have even in America excited concern. In considering this subject, Mill proposed that there should be a moderate limit to the amount one might legally receive by gifts and bequests; and the same thinker, and others of equal eminence, have declared their conviction that land shall at some future time, near or remote, be redistributed on some equitable plan.

The law of heredity has an important bearing, not only on questions of education and property, but also on the problem as to the best treatment of the criminal classes. Since the human character is so much dependent on inheritance, and so indelibly impressed by depraved associations in early life, it is thought that all incorrigible offenders, as soon as their state can be proved, should in some right way, by imprisonment or otherwise, be prevented from propagating their kind. Dr. Dugdale, of New York, followed the lines of descent from one Margaret Jukes, through six generations, including in all seven hundred and nine persons — thieves, prostitutes, murderers, and idiots. The Chinese so firmly believe depravity to be a taint of blood, that a criminal's father and grandfather are sometimes required to perish with him; conversely, this nation of ancestor-worshipers deem a man so much indebted to his parents for all that makes him great, that when a citizen is ennobled for eminent services, titles are bestowed upon the ascending line of the family, and not the descending, as with us.

Important as the relations of the law of heredity may be in the various topics adverted to in this paper, none can be so much so as the comprehension of the law, and obedience to it in marriage. The lower animals are carefully bred, while men and women mate with rarely any rational reflection as to their fitness for each other, thus often entailing upon themselves and their offspring woes unspeakable. The plain sense which should forbid the consumptive, syphilitic, or scrofulous, from marrying is disregarded, and the results are terrible. When one's constitution is impaired by some not serious organic ailment, special pains should be taken to avoid the like in selecting a partner for life. Physi-

ologists deem consanguineous unions to result as badly as they often do from the parents inheriting from their one common stock similar weaknesses which unite in their children to form a lower deep of organic deficiency. With very good constitutions, men have been known to marry their sisters with impunity, as some of the Ptolemies did; but, when the stock of the Egyptian monarchs declined in soundness, their close intermarriages resulted in a rapid and frightful degeneracy.

Where there is no blood relationship between parents, they sometimes produce booby children, from having a too close temperamental similarity. The most trustworthy authorities on this subject say that in marriage a moderate difference between the constitutions and characters of the parties, and complementary rather than antagonistic, is best. A noteworthy consideration in selecting a wife is, that as a mother has much more influence on a child's character than a father, if she has any marked bad trait, as a violent temper, laziness, or vanity, and if that trait be transmitted to her offspring, then the child will be brought up by a woman the least fit of her sex to recognize the child's faults, and eradicate them as far as possible by proper training. In the rearing of young children, close associations have great influence. A professor of McGill University assures me that the infants of his family acquire a resemblance to their nurse in expression, which only disappears when they are removed from her.

A happy and hopeful marriage may be marred in its results from procreation taking place while sickness, anxiety, or grief, has lowered vitality; and the too frequent bearing of children is very seriously detrimental to both mother and progeny.

When a parent transmits a malady, carefulness in living can frequently prevent its development; but when disease or predisposition to it is acquired from a parent together with the carelessness or self-indulgence of character which originally induced the disease, then the taint of blood is confirmed and increased. Many persons of weak frame prolong life to old age by prudence and abstemiousness, whereas the conscious possession of a vigorous constitution is a constant temptation to abuses of it. Length of days depends less upon the quantity of vital energy received at birth, than on the jealous care of health and strength.

In these matters, as in all others, we not only need to know much, but to know it so long that we shall act upon our knowledge. The discrepancy between the intellectual acceptance of truth and moral obedience to it is wide as the gap between Ideal and Real.

THE PHYSICAL FUNCTIONS OF LEAVES.

AN elaborate study on the above subject has lately been published by Prof. J. Boussingault, of Paris, in the "Annales de Chimie et de Physique" (vol. xiii., pp. 289–394), in which the phenomena of absorption and transpiration by leaves are treated at great length. Since the memorable experiments of Hales in 1727, recounted in his work on "Vegetable Statics," this branch of vegetable physiology has been rarely touched, and the carefully recorded observations of Boussingault, carried out with the best of modern scientific appliances, possess an unusual value.

The first point studied was the loss of water by transpiration from the leaves of plants under normal circumstances. For this purpose a healthy Jerusalem artichoke (*Helianthus tuberosus*) in a roomy flower-pot was chosen. The top of the pot was covered with a sheet of India-rubber, tightly inclosing the stem of the plant, and provided with an opening for the admission of water. The whole was then weighed, and the loss noted which ensued under various circumstances, by evaporation of water from the leaves, the plant receiving during the experiment weighed normal amounts of water. The total surface of the leaves of the plant (both upper and lower sides) was carefully estimated, and the result reckoned on the square metre. The averages of fourteen experiments showed that the artichoke lost hourly, for every square metre of foliage, the following amounts of water: in the sunshine sixty-five grammes, in the shade eight grammes, during the night three grammes.

In the next place the question was investigated whether the absorption of water by plants and the ascent of the sap are due to the force resulting from the transpiration on the surface of the leaves, or whether the roots exercise also a certain amount of force to this end. For this purpose experiments similar to the above were carried out with various plants, firstly under normal circumstances, secondly with the stem minus the roots immersed in water. As an instance we can take mint. The plant with roots showed an hourly evaporation per metre of eighty-two grammes in the sunshine and thirty-six in the shade. Under the same condition without roots, the evaporation was sixteen and fifteen grammes respectively.

The results show that the absorption of water by plants is determined in a great measure by the transpiration occurring in the leaves, that this is maintained for a certain length of time without the assistance of the roots, but cannot continue long, being dependent on the injective power possessed by the roots. The effect of pressure on the absorption was next examined, and it was found possible by this means for a time in certain cases to even more than replace the water lost by transpiration. For example: a chestnut-branch dipped in water was

found to transpire hourly per metre of foliage sixteen grammes. It was then inserted into a tube of water, and subjected to the pressure of a column of water two and a half metres high. Under these conditions the evaporation mounted to fifty-five grammes per hour, and the branch at the end of five hours weighed more than at the commencement.

The general result of these experiments shows the mutual working of the various parts of the plant with reference to the phenomena of transpiration. The roots, absorbing water from the soil by endosmose, direct it toward the stem. Whether the motive force here is injection by the roots or absorption resulting from the transpiration in the green parts of the plant, or a union of both, is a question still unsettled. The

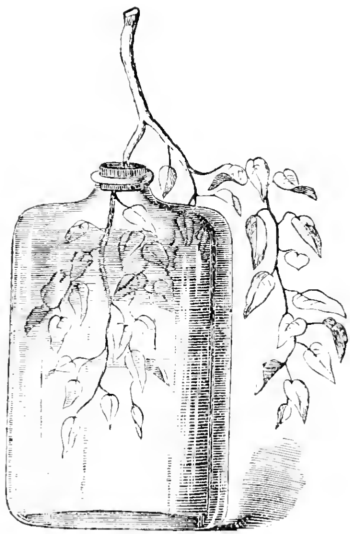


Fig. 1.

Fig. 2.

stem serves not only as a passage for the water to reach the leaves, but also as a reservoir to be drawn on during rapid evaporation. In the leaves the sap is concentrated by the transpiration, and the matters in solution enter into the cell formation, or, changed by the action of light, are distributed throughout the plant by the descending sap. The circulation would be quite similar to that in an animal, were it not for the irregularity. While the supply of water from the roots varies but slightly, the loss by evaporation from the leaves is subject to the greatest fluctuations, according to the temperature and hygroscopic condition of the surrounding air. During these periods the leaves draw on their stock of constitution water and the supply in the stem; and when both fail, the phenomenon of wilting ensues.

Numerous experiments were made on the difference in *evaporation during the day and during the night.* Those carried out with leaves of the grapevine gave the following hourly averages per square metre of foliage: in sunshine, thirty-five grammes; in shade, eleven; during the night, 0.5. The trellis on which the vine was trained was one metre high and thirty-eight metres long, and presented a surface of one hundred and thirty-eight square metres of foliage. In sunny weather this would lose by evaporation, in the course of twenty-four hours, forty-eight kilogrammes of water, and nearly half of that amount during cloudy weather. To give an idea of the enormous amount of aqueous vapor dissipated by plants in the sunshine, calculation showed that an acre of beets could lose in the course of twenty-four hours between 8,000 and 9,000 kilogrammes. Another experiment made with a chestnut-tree thirty-five years old showed that it lost over sixty litres of water in the course of twenty-four hours. The structure of the leaf, however, containing seventy to eighty per cent. of water, and possessing a thickness frequently of but one-tenth of a millimetre, would suggest the question why the evaporation is not much more rapid. The answer to this is found in the peculiar structure of the tissue forming the epidermis, designed especially to moderate the transpiration. In order to see the remarkable retentive power exercised by this epidermis, one can expose for a few hours to the sun two cactus-leaves of the same superficies, one of which has been deprived of its epidermis. The evaporation in the latter case will be about fifteen times as rapid as in the other. It is the presence of a similar tissue forming the skin of fruits which prevents an otherwise rapid evaporation. For instance, an apple deprived of its skin loses fifty-five times as much water as a whole specimen in the same time. Losses by rapid evaporation lessen notably the physiological energy of leaves. Thus an oleander-leaf containing sixty per cent. of water, when introduced into an atmosphere containing carbonic acid, decomposed sixteen centimetres of this gas; one containing thirty-six per cent. decomposed eleven centimetres; and one containing but twenty-nine per cent. was without action.

A series of observations was made on the relative powers of *evaporation on the upper and lower sides of leaves.* They consisted in plucking two leaves of the same kind at the same moment, covering on the one the upper, on the other the lower side with melted tallow, and then noticing the loss of weight by evaporation in a given time. The average of the results showed that the proportion between the amounts of water evaporated on the upper and lower side of a dozen varieties of leaves was 1 : 4.3. In all cases the amount evaporated from the two exposed sides of two equal leaves was greater than from the entire surface of a similar leaf under the same circumstances.

A point of no small interest with regard to the physical function of leaves is that of their ability to replace the roots of a plant in serving as the agent of absorption. A variety of tests were undertaken to set-

tle this question; among them the following: A forked branch of lilac (Fig. 1) was so disposed that the one branch was immersed in water, while the other was exposed to the ordinary atmospheric conditions. The superficies of foliage was the same on both branches. The transpiration from the surface of the leaves on the latter branch was the same as under normal circumstances, and after the lapse of two weeks the foliage was as fresh as at the commencement, showing that the submerged leaves were fully able to replace the roots in one of their functions. In an experiment with a beet in which one-half of the leaves were in water and one-half in the air, communication being maintained by means of the root, the free portion of the leaves wilted in the course of a day, the neck of the root apparently not offering a sufficient means of communication with the submerged leaves. A grapevine shoot half plunged in water (Fig. 2) maintained a normal evaporation in the free foliage, and remained fresh for over a month. An oleander shoot under similar conditions maintained its normal appearance for four months. With the artichoke it was found necessary that the surface of the leaves beneath the water should be four times that of the leaves above.

Closely bordering on this question is another which has excited much dispute, viz., the ability of leaves to draw water from the surrounding air or by immersion, after having suffered losses by transpiration. Prof. Boussingault's numerous experiments show that leaves, after having been exposed to influences causing a rapid evaporation, are able to absorb water rapidly on immersion, and even from an atmosphere saturated with aqueous vapor. There is, however, in both cases no absorption unless the leaves have lost a portion of their water of constitution, i. e., that which is essential to their normal existence. Thus, a wilted branch of periwinkle weighing 4 grammes, after remaining in an atmosphere saturated with aqueous vapor for a day and a half, weighed 4·2 grammes, and after twelve hours' immersion in water 9·4 grammes.

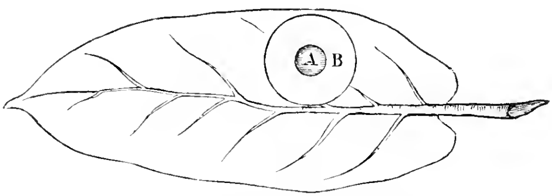


Fig. 3.—*A*, drop of solution; *B*, watch-glass.

The last function of leaves studied by Prof. Boussingault is their ability to absorb solutions of mineral matter, i. e., perform another of the ordinary duties of the roots. For this purpose a solution of gypsum containing $\frac{2}{1000}$ of solid matter was used. Drops of this solution were placed on the leaves of a great variety of plants—under conditions favoring absorption, as in the experiments just described—and protected

from evaporation by superincumbent watch-glasses with greased edges (Fig. 3).

In most instances the drops were absorbed entirely, leaving no traces of the mineral matter; in some cases a slight residue was left, which the addition of a minute quantity of water caused to disappear. As in the case of pure water, the under side of the leaves absorbed much more rapidly than the upper side. Solutions of sulphate and nitrate of potassium gave quite similar results; the absorption of solutions of chloride of sodium and nitrate of ammonium was not so perfect. These results would tend to show that the foliage of a plant is able to supply it with perhaps no small portion of its saline constituents by means of the ammoniacal salts formed in the air, and the alkaline and earthy salts suspended there which are deposited on the surface of the leaves by rain and dew.—*Nature.*

CURARI OR WOORARA POISON.[1]

By MAURICE GIRARD.

IT is almost three centuries since Sir Walter Raleigh, after the discovery of Guiana, brought to Europe some arrows poisoned with a substance called by him *curari.* This poison was then in general use among the tribes inhabiting the Atlantic slope of South America. To-day we must penetrate into the depths of the forests to find the remnants of the ancient populations who possess the recipe for preparing curari. It may safely be affirmed that by next century it will have disappeared, either through the annihilation of these races, who are vanishing before the whites, or blending with them by intermarriage, or, above all, because firearms, obtained by way of barter from European traders, are steadily superseding the ancient implements of war and of the chase.

The arrow-poison is usually prepared from a substance often called *veneno* by the Spanish-Americans, and which occasionally happens to be brought to Europe under the name of *curari.* This substance, which the natives carry about in little earthenware pots or in calabashes, is a black, solid extract, with glistening fracture, in appearance very much like the black, inspissated juice of licorice. The active principle of curari is soluble in water, alcohol, blood, and all animal fluids; it is mixed with many impurities, which remain suspended in the solution, and among which the microscope detects vegetable *débris,* cells, and fibres. Ether and spirits of turpentine precipitate the curari poison, and in this way Messrs. Boussingault and Roulin have been able to isolate the active principle of curari, which they call *cu-*

[1] Translated from *La Nature* by J. Fitzgerald, A. M.

rarin. Its chemical constitution is not yet made out; it is not crystallizable, has the look of horn, is very hygroscopic, and easily soluble in water and in alcohol. The watery solution is not affected by boiling, and appears to preserve its toxic property for an indefinite time, precisely like the dried curari on the tips of arrows, a circumstance which renders these weapons very dangerous objects to handle.

Curari is prepared at long intervals by the natives of South America, whenever the supply, which is divided between the hunters and the warriors, has become exhausted. The mode of preparation differs according to locality, but these differences are not essential. The ingredients are everywhere either the same or at least analogous, for the curaris manufactured in different regions amid the almost unexplored forests of Guiana and Brazil always present the same toxic properties. Sometimes curari is prepared openly and without mystery on some high festival of the tribe, with the usual accompaniment of copious libations of strong drink. And, by-the-way, it has been remarked by Humboldt that during a festival it is a rare thing to find a native that is not intoxicated, drunkenness being unfortunately, in all latitudes, the habitual expression of gladness among the ruder classes of mankind.

At other times the arrow-poison is prepared only by the medicine-men, who hedge its preparation around with superstitious practices and mystic ceremonies, designed to enhance their own prestige and influence. The exaggerated reports of travelers have still further complicated the matter, as when we are assured that in the preparation of the curari some old hag of the tribe shuts herself up in a hut with the kettle in which the poisonous ingredients are boiled, and that, if the process is successful, she herself dies by inhaling their noxious emanations. This is a fable, for curari is not volatile.

It has also been stated that, when the curari begins to thicken, the natives throw into the pot ants with venomous stings, and the fangs and poison-glands of the most deadly serpents, such as the rattlesnake. Possibly these accessories may have sometimes been employed, but we now know that they are not essential, and that excellent curaris are prepared solely from vegetal substances. According to Goudot, the tribes living on the New Granada frontier cut down in the woods certain climbing plants of the genus *Strychnos*, from which exudes at the cuts a quantity of acrid sap. The wood is crushed and macerated in water for forty-eight hours; it is then pressed, and the liquid is carefully filtered. After filtration it is slowly evaporated, till it reaches the required degree of concentration. It is now distributed among a number of little earthenware pots, which are placed on hot embers, and the process of evaporation is carried on with still greater care, till the poison acquires the consistence of a soft paste and is perfectly free from water.

Dr. Jobert is now engaged in studying in their native habitat the properties of the various plants which are known to have been em-

ployed in the preparation of curari, and he has had prepared under his own supervision, entirely from vegetal substances, one of the best of American curaris, that of the Tecuna Indians living on the Calderão, Brazil, near the Peruvian border. Some fine scrapings of *Urari uva*, a climbing plant of the genus *Strychnos*, and of the *Eko* or *Pani*, of the family *Menispermaceæ*, also a climber, were steeped in cold water. This liquid was then boiled for six hours, and there were thrown into it fragments of various plants, among them an *Aroidea* (*Taja*), and three different species of *Piperaceæ*. In this way the liquid was made to assume the consistency of mucilage ; it was then suffered to cool, and became as thick as shoe-blacking. Dr. Jobert has found by experiment that the *Urari* and the *Taja* are the most rapidly fatal in their effects of all the ingredients, and that the *Pani*, administered by itself, is less rapid.

The Indians use curari to poison their arrows both for hunting and for war. The hunting-arrows, intended to be shot from a bow, have a detachable point ; those shot from the *sarbacand* or blow-gun are very small, and consist of a slender shaft of iron-wood with a very sharp point, which bears the poison. Sometimes the poison is used highly diluted or in very small quantity, so as to produce in the victim simply a numbness, which passes away by degrees, but which in the mean time checks the animal in its course or in its flight, or causes it to fall from the tree in which it may happen to be. It is thus, we are told, that the Indians capture monkeys and parrots for sale to the European traders. Often the animal is killed by the arrow, but nevertheless its flesh may be eaten with impunity, for the very minute dose of the curari which enters the stomach with a mass of food is innocuous. Indeed, we know that curari, like the venom of serpents and the saliva of a rabid dog, may be introduced without injury into the digestive organs, provided the mucous surfaces of the latter are free from all lesion.

Curari has been mixed with the food given to dogs and rabbits in quantity far more than enough to produce fatal poisoning through a wound, and yet the animals have suffered no inconvenience.

Claude Bernard, however, has very clearly shown that this innocuousness of curari when administered through the stomach is relative only. In this respect curari resembles many other substances, both medicines and poisons. The peculiarity of their action is explained by the property which amorphous substances possess of being very slowly absorbed by the mucous membranes. By young mammals and birds while fasting, and while intestinal absorption is very active, curari cannot be taken into the stomach with impunity. We can only say that it takes a much larger quantity of curari to produce poisoning through the digestive organs than through an external wound.

Curari introduced into living tissues produces death all the sooner the more quickly it enters the circulation. Death comes quicker when

a solution of curari is injected under the skin than when the dry poison is introduced by the point of an arrow. Vigorous animals with rapid circulation of blood are more easily poisoned than those which are weakly; and with an equal dose of poison and with animals of equal size, those whose temperature is constant die more quickly than those whose temperature is variable (reptiles, batrachians, fishes), and, among the former, birds succumb more quickly than mammals.

The animal at first does not feel the wound, for curari possesses no caustic property. In the case of very small animals death is almost instantaneous. In birds and mammals of a large size, and in all animals of variable temperature, death usually occurs in from five to twelve minutes, if there is an excess of the poison. The animal lies down as though it would sleep, keeping the eyes open, with a placid expression. Soon it is seized with a progressive paralysis of the motor nerves, proceeding from the extremities to the centre. The muscles of respiratory movement are the last to succumb, and the animal dies from asphyxia.

To all appearance, nothing could be calmer than this progressive state of stupor; there is no agitation, no expression of suffering. The mouth remains shut, without foam or saliva. Life seems to be extinguished slowly, like some liquid that gradually flows away. In view of these treacherous symptoms, a member of the Society for the Prevention of Cruelty to Animals might be tempted to urge the use of curari in lieu of the brutal modes at present in vogue for slaughtering old, worn-out horses.

To Claude Bernard science is indebted for the exact determination of the specific action of curari. Vital activity presents a threefold series of distinct and coördinated organic elements, which play the part of excitants of one another. The starting-point of physiological action is the sensitive nerve-element. Its vibration is transmitted along its axis, and on reaching the nerve-cell—a regular relay—the sensory vibration is transformed into a motor vibration. This latter, in turn, is propagated through the motor nerve-element, and on reaching its peripheric extremity causes the fibre of the muscle to vibrate, and this, reacting in virtue of its essential property, produces contraction, and consequently motion.

Now, each of the three elements, sensory, motor, and muscular, lives and dies after a fashion of its own, and there are poisons proper to each. But, inasmuch as vital manifestations require the coöperation of these three activities, if one be suppressed, the other two continue to live indeed, but they no longer mean anything, just as a phrase loses its meaning if one of its members be dropped out. Claude Bernard's experiments have proved that the motor nerve-element alone is affected by curari, and that the other two organic elements of the animal retain their physiological properties. The mind is not destroyed, the muscular fibre still has the power of contraction, and indeed does contract under the influence of electric discharges. Motor power alone is de-

stroyed; if the characteristic manifestations of life have disappeared, it is not because they are really extinguished, but because they have been one after another turned back by the paralyzing action of the poison. In that motionless body, back of that lack-lustre eye, with all these semblances of death, sensibility and mind still persist intact; what looks to be a dead carcass hears and knows all that goes on around it; it feels pain when its body is pinched or burned; it still has feeling and will, but it has lost the instrument needed for manifesting them. The movements which are most expressive are the earliest to disappear—first voice, then the movements of the limbs, those of the face and the thorax, and lastly the movements of the eyes.

Is it possible to conceive a more dreadful torture than that endured by a mind which thus witnesses the privation of its organs one after another, and shut up, as it were, in the fullness of life within a corpse?

MOLECULAR DYNAMICS.

By L. R. CURTISS.

DYNAMICS refers to force or power. It deals with the primary conceptions of energy in its relations to subjects that are susceptible of numerical estimation, such as time, space, and velocity. Or, again, dynamics is that branch of science which measures the energies producing motion as well as those produced *by* motion, and is divided into two parts—kinematics, which pertains to motion without regard to the bodies acted upon; and kinetics, which refers to the cause of energies whereby motion is given to bodies, each of which is the antithesis of static energy or energy at rest. Molecular dynamics has for its domain the actual working forces inherent in the atoms and molecules of matter. This branch of the subject bears the same relation to physics as the differential calculus does to mathematics, and by thus dealing with the physical molecules and atoms we are enabled to extend the kinetic chain of causation down toward the infinitely small with a certainty almost parallel to the accuracy with which the integral calculus defines the motion of the planets.

The text-books teach us that one of the properties of matter is inertia, including both that of rest and that of motion, the former being defined as the passive condition of bodies when at rest. This definition refers to matter as a mass. The new philosophy, however, teaches that, since molecular motion refers to the invisible movements of the particles of the mass, there is no such thing as complete rest of the ultimate particles of matter short of absolute zero of temperature, which, if universal, means total frigidity of every sun and orb in the universe.

The current of scientific thought tends to demonstrate that all the

phenomena of Nature are to be regarded merely as varieties of motion, one guiding principle of which is conservation of energy. This being an established fact in science, it fortifies us in our position of reasoning downward in the direction of primary causes. By conservation of energy we are to understand that, while matter exists throughout the universe in definite quantity, there is also existing, as an attribute of matter, a definite amount of energy or force; and just so sure as matter is indestructible and *un*changeable, just so sure is force or energy indestructible and *inter*changeable. That is, matter and force are both indestructible, but force or energy (synonymous terms) is convertible into the several modes of force. The attributes of matter are attraction of gravitation, attraction of cohesion, and chemical affinity. Attraction of gravitation is a force exerted upon each and every atom of matter throughout the universe, with a never-ending geometric ratio, varying directly as the mass and inversely as the square of the distance. The force known as chemical affinity binds the integral particles of compounds in an embrace many millions of times stronger than that of gravitation, but, like cohesive attraction, is incompetent to exert its power beyond very short distances, such as those measured by the limits of the molecule.

The correlation of physical forces has for its domain the interchangeableness and universality of the forces of Nature. It is competent to solve the dynamical problems of vital and physical phenomena, demanding from every antecedent its consequent, and exacting from every consequent an equivalency of antecedent. All sound experience of whatever kind justifies this affirmation. These views compel the idea of the universality of motion, and that force is the eternal causation of each and every phenomenon, and that the existing relations between matter and force remain constant throughout the universe. The same forces that whirl suns and planets in a restless march through shoreless space measure the phenomena of the moments of life.

The different consequents of molecular motion are sound, light, heat, etc., the antecedents of them all being some mode of motion. By the term "mode of motion" is meant the manner in which energies are made sensible to our understanding. Thus, the terms heat, light, etc., are but familiar ones by which we express the various modes in which force is exhibited to our senses in its action upon matter. Conservation of energy was denominated by Faraday as "the highest law in physical science which our faculties permit us to perceive." Its unfoldings mark an intellectual epoch which divides the old from the new. It teaches of the unity of the universe; it tells us how the sun's rays constitute the mighty energies of daily life and action upon every hand, warming, illuminating, and vivifying the surface of the globe.

As an illustration of this interchangeableness of force: suppose two files of men to be arranged in proper order, between which we roll a cannon-ball with a certain initial velocity. This ball runs the gantlet

of those files of men, it being the individual duty of each man to retard the momentum of the ball by interposing his hand in its path. It is evident that each hand so interposed will receive a shock, the force of which is just equivalent to the amount parted with by the ball itself. Finally, the ball comes to rest. The original momentum of the ball has for its equivalency the sum total of the lesser energies imparted to the several hands interposed. Or again, if, instead of hands interposed, we substitute a row of smaller balls, and let them receive the impact of the moving one, the result will be just the same. Each and every ball interposed will have the motion of its constituent particles augmented by an amount of energy of motion exactly equivalent to that parted with by the larger ball; and, when the moving ball finally comes to rest, the sum total of molecular energies in the interior of each ball is exactly equal to the original momentum of the larger ball. Thus we have an illustration of the transference of molar into molecular motion, the molecular motion making its appearance as heat, one of the modes of force. If you push endwise against a stick of wood, the force applied will immediately appear at the other end. This is transmission of force by means of molecular action. The force being applied to one end of the bar is transmitted from particle to particle with great velocity its entire length. If a row of bricks be properly placed, any force applied to the first of the row, sufficient to topple it against the next, will be transmitted throughout from the first to the last of the series. Or again, if the bar of wood be pushed against one end of our imaginary row of bricks, we shall have in the rod and in the falling bricks a continuous chain of similar phenomena, the action of the bricks being a *visible* illustration of the transmission of force, and highly analogous to that *invisible* transmission along the molecules of the bar.

Apart from the different modes of force, we have energy in two forms—static or potential, and actual or dynamic. The potential has been likened to a weight wound up, and the actual to a weight in the act of falling. The amount of energy expended in winding up the weight, less the friction, is exactly equivalent to the potential energy of the weight so raised, also to the dynamic energy given out by its falling or running down. The inherent measure of force possessed by each and every atom is its kinetic energy, and this energy is the correlative and antecedent of all the modes of force which characterize the various phenomena of the visible universe. The condition in which matter presents itself to our senses depends upon the degree in which these several forces are made manifest. All the phenomena of Nature consist in transformations of energy only, the working force of the universe being previously invested in the kinetic energy of its atoms.

The potential energies of the atoms of matter, in their free condition, are almost beyond human comprehension. Thus, heat a pound of charcoal to the point of incandescence. The vibratory motion of the atoms of carbon will then have reached an amazing velocity; oxygen

rushes in to form new compounds; the oxygen-atom, by its impact upon the coal, has its motion of translation converted into vibratory motion, which immediately appears as heat. The clash of these atoms makes up the sum total of the energies of the combustion. The actual amount of dynamical energy set free by the union of this pound of charcoal with atmospheric oxygen is equivalent to the mechanical raising of eleven and a quarter million pounds one foot high. Let us further consider the dynamical forces inherent in the molecules of free gases, and look to a molecular explanation of the three states of matter, the solid, fluid, and gaseous. In solids the atoms are held together with a rigidity that develops the full strength of cohesive force. In liquids the same attraction is so far lessened that a definite form can only be preserved in a limited degree, as in drops of water maintaining a spheroidal shape against the force of gravity. In the gaseous form atoms do not cohere, the cohesive force having been translated into the energy of motion, and it is this energy of motion which constitutes the expansive force of confined gases.

Suppose we have a vessel containing eight pounds of oxygen and one pound of hydrogen. This mechanical mixture of gases, invisible though it be, and harmless as it appears, is the theatre of energies wholly beyond our conceptions. Figure to your imagination these gases made up of atoms so small that a billion times a billion would scarcely fill a cubic inch, and all these atoms vibrating among themselves without actual contact. Although the minute distances over which these atoms travel are utterly immeasurable by direct appliances, we shall presently see that the energies evolved by the clash of their chemical union is something prodigious. The concussion of atoms at the union of eight pounds of oxygen with one pound of hydrogen sets free an amount of energy, in the form of heat, equivalent in mechanical value to 47,246,400 pounds let fall one foot, or the crash of a ton's weight as an avalanche down a precipice of 23,623 feet.

The three states of matter have been likened to three planes, of which the gaseous is the uppermost, the fluid occupying the intermediate plane, and the solid state for the lower one. The clash of atoms at the union of the two gases has resulted in the liberation of the energy above mentioned, but a change of state has taken place, and we now have water in the vaporous condition occupying the intermediate plane. This nine pounds of steam in condensing to water sets free an energy, the mechanical equivalent of 6,722,000 pounds let fall through the space of one foot. The next change takes us past the reduction of the temperature of the water from the boiling to the freezing point, setting free both the specific and latent heat of the water. This final fall to the plane of congelation occasions a further dissipation of energy equivalent to 2,237,256 foot-pounds, making a grand total of 56,000,000 foot-pounds as the measure of energy in our nine pounds of invisible gas.

The verity of these statements might be questioned were it not that

the most refined researches give unvarying results. Suppose we reverse this experiment, and, commencing with nine pounds of ice, we will, by a process of mental abstraction, again bring our conceptions down to the immeasurably small, and fix our attention upon the molecules of the ice. Figure to yourself the atoms of each molecule as being in oscillation through points of equilibrium. And, while your attention is centred upon the motions taking place in the interior of the mass, we will let fall upon the block of ice a concentrated beam of sunlight, and see how it deals with the inherent forces of cohesion and chemical affinity. The solar undulations impinge upon the molecules of the ice, and, under this bombardment of heat waves, see how rapidly the atoms accelerate their motions! All this while the contest is going on between the dynamic energy of the sun's waves of heat and the cohesive force of the molecules. Beautifully and symmetrically the forces of Nature built up the crystalline mass, and as silently and surely the sun's competency of heat will effect its liquefaction. Thus far we have seen the atoms accelerating in velocity by virtue of the energy imparted by the solar-heat waves, and all this time they are vibrating within the definite limits of the molecule. A further increase of heat will increase the motion of the atoms, thus tending to a rupture of the bonds of cohesive attraction. The struggle goes on until the ice melts, by which process we have solar energy conserved in the latent heat of water. The molecules being thrown almost beyond the range of cohesive force, their movements are no longer confined to their former limits, but may extend throughout the length and breadth of the mass. This is the fluid state. The amount of energy required to swing the atoms so nearly beyond the range of cohesive attraction, or simply to melt the ice, is equal to 500 tons raised one foot high. This force still exists as transmuted energy, and is the latent heat of water. A further addition of heat takes the form of increased vibratory action up to the boiling-point. Then comes another struggle seven times greater than the first. This last remnant of cohesive force of water must be surrendered, and the heat-energy necessary to perform the act is conserved or transmuted into the latent heat of steam. The last vestige of cohesive force now being gone, the molecules of steam are free to oscillate in all directions, and impinge against the walls of the containing vessel. If we continue the application of heat to the point of dissociation, the molecules of vapor will have acquired a momentum sufficient to rupture the bonds of chemical affinity. And here the energy required to separate the molecules of steam into its constituent atoms of oxygen and hydrogen is simply prodigious, being about forty-eight times as much as was necessary for the process of liquefaction. Thus the aggregated energies required to set free the oxygen and hydrogen in our nine pounds of ice are equivalent to the raising of a ton's weight 28,000 feet, and we now have the original nine pounds of gas, laden with the potential energies of 56,000,000 foot-pounds, which is just

equivalent to the requisite liberation of force necessary to reduce the gases back again to the solid form of ice. A cubic foot of water yields 1,862 cubic feet of the separate gases when at normal condition, and no human device is competent to overcome this expansion by pressure sufficient to reduce them back again to the liquid condition. Upon the evidence of Faraday we have it that "the decomposition of a single drop of water by electricity calls for an expenditure of more electromotive force than would suffice to charge a thunder-cloud."

Our main source of dynamic energy is from the sun. His energy is exhibited in every wind that blows, in every shower that falls, and in the history of every snow-flake—in the glare of gaslights, in the heat of the furnace, in the colors of the rainbow, and in the gorgeous sunset, in the beauty of vegetation and its silent growth. Thus, in an almost infinite variety of physical phenomena we see this transmutation of solar energy. This energy, after doing its allotted work, is in time dissipated into space by radiation. And, were it not for the intermediate position of the vegetable kingdom to check this degradation of energy and raise the elementary constituents from the chemical to the organic plane, man's duration here would be short indeed. The locking up of potential energy in the protoplasmic cell of the plant requires the expenditure of a vast amount of energy, but the solar ray, aided by the subtile alchemy of the leaf, is competent for the task; and, while the chlorophyl of the leaf assists in weaving organic tissues from the air, this outward dissipation of energy is delayed for a while, giving us food for our bodies and fuel for our fires. This final process of combustion once more converts these potential energies into the dynamic form and sets them free to dissipate into space. All the mechanical power which comes from the combustion of fuel and all the muscular force of the animal kingdom is but the transmutation of solar energy through the mediumship of plant-life. Well might we say, as did the pagans of old, "We are children of the sun." This flood of solar force is unceasing. Waves of ether may conduct a store of energies across the universe and invest them in a wealth of carbonaceous flora; these energies may lie dormant in vegetable fossils for untold eras; man may delve in mines and exhume the coal, and enlist the aid of oxygen to break the bonds of chemical affinity, setting free those energies stored away in the countless ages of the past; he may unfold link after link of the great dynamic chain of causation, and subject them to the scrutinizing analysis of the physicist; he may survey the rocks and tell us of their radiations of internal heat, or by his calculus tell us for how long in the past this planet may have been the theatre of life and death; he may tell us, not only of the energies in the atoms of a drop of water, but of a world of atoms—nay, more, of a universe made up of atoms with their energies drifting out into measureless space; but he can tell us naught of that unseen universe into which the energies of the visible creation are ever tending.

While dealing with the forces of Nature from an atomic standpoint, we are treading upon the border-land of science, beyond which all sensible phenomena have their origin.

Science may, by spectrum analysis, determine the constitution of the irresolvable nebulæ; it may tell us of the millions upon millions of ethereal waves necessary to impinge upon the retina to produce a given chromatic effect; it may measure the waves of air that roll as music down upon the tympanum of the ear: but *how* undulations upon the retina or vibrations of the auditory nerve are converted into consciousness of sight or sound, is a question which, like the causation and mystery of life, belongs to that realm outside of the domain of science—a realm the infinite mystery of which transcends all analysis!

In conclusion, let us not be led into a rigid belief that the present views of molecular physics are competent to explain all the phenomena that may be presented for solution for all time to come. It is enough to say that it answers our purpose in giving a satisfactory explanation of a large class of natural phenomena as they are exhibited to us in daily life. But, as we know the favored ideas of scientists and scholars in generations preceding ours have given way to newer and better ones, so, in turn, the popular conceptions of to-day may serve as stepping-stones to coming ideas, each destined to take its place as the predecessor of a higher and better intelligence.

EFFECTS OF ALCOHOLIC EXCESS ON CHARACTER.[1]

By J. MILNER FOTHERGILL, M.D.

A GREAT deal of attention has of late years been bestowed upon the subject of alcoholic indulgence. The importance of the subject warrants this, and even calls for still further attention. There are differences of opinion as to the use of alcohol; there are comparatively none as to the abuse of it. Leaving then, for the present, the question of the use of alcohol in disease, its effect upon the body temperature, and its position as a food, we may profitably engage ourselves for a little time with its social effects, alike upon the individual and the masses, especially in reference to its influence upon the mental manifestations of brain-activity. It is now universally acknowledged that mental alterations follow physical modifications of the brain, as seen in the various forms of insanity. We well know how profound is the influence exerted by alcoholic excess upon the brain, and through it upon the character. Unfortunately, the effects of continued alcoholic excess are but too frequently forced upon our attention.

[1] Read before the Social Science Congress at Liverpool.

The most pronounced product is found in the hopeless drunkard, who, in squalid rags, with rotten tissues, the embodiment of intellectual and moral degradation, utterly beyond hope, the line of possible restoration long past, hangs around the tavern-door, and, with the odor of alcohol floating on his breast, whiningly begs a copper from the mass of vitality around him, of which he himself is a withered and decaying branch. This man is incapable of labor; he is unwilling to entertain the idea of toil. He is beyond any capacity for labor; he is no longer capable of discharging his duty as a citizen; he is a social parasite of the lowest and foulest order, as useless as a tapeworm. He has abandoned all self-respect, because there is nothing left in him for himself or any one else to respect. He is a shameless liar, who will make the most solemn protestations as to the truth of what it is patent enough is false. There is no depth of moral degradation to which he will not descend for the means to purchase a little more of the fluid which has ever been his bane.

Betwixt him, however, and his patrons, many of whom enter the tavern to celebrate some little matter by a glass together, there is a potential association, not always at first sight readily apparent. The effect of alcoholic indulgence is seductive; and it often creeps on unobserved, doing much irretrievable mischief ere its presence is unmistakable. It is not the intention of the writer here to discuss the question of the moderate use of alcoholic beverages, but rather to point out the fruits, the evil consequences, of excess. Betwixt the hopeless drunkard and the casual taker of a social glass there are a thousand grades and modifications. Nor does it necessarily follow that the one shall degenerate into the other; very commonly he does not; but, unfortunately, he may, and not unfrequently does. Too frequently, indeed, the practice grows, especially in those who naturally lack self-restraint, or cannot control their impulses, however capable in other respects. The dangers of alcoholic allurement are various in their degrees of potency in different individuals.

Not only that, but there is no little influence exercised by the immediate motives for which alcohol is taken. The future progress of the individual indulging in alcoholic excess is widely different, according to the mental attitude at the time. Thus, betwixt the man who has been taking alcohol to excess at intervals extending over many years, and the young woman who is just commencing to drink because she is unhappy, there is a wide gulf. The one, so far as the alcohol is concerned, will probably live to an advanced age; the prospects of life in the other are very poor, and the ruin will be swift and complete. In the one there are long intervals of sobriety, during which the effects of the debauch will, to a great extent, wear off; in the other the act will be repeated as often as opportunity will permit; one act of indulgence will lead to, indeed will induce another, and the oft and quickly repeated act will become a constant habit, whose effects are soon felt.

It is not in women alone that the hopeless nature of drinking habits in certain susceptible organisms is manifested; it is equally seen in men where the nervous system lacks stability.

The deceptiveness, the utter untrustworthiness, the subtle craft, the falsehood, which women of culture even will develop under the influence of alcoholic cravings, have shocked many persons. The habitual drunkard, however produced, always exhibits these characteristic signs of moral degradation. The deterioration of character produced by protracted drunkenness is notorious. While the intellect becomes enfeebled by excess, the moral character becomes profoundly modified; the forces which ordinarily restrain others are in abeyance—perhaps too often their influence has gone forever; the indifference toward the interests of others progresses alongside a waxing selfishness, a complete absorption in self. So long as they can procure what they themselves crave for, confirmed drunkards are indifferent as to how others may suffer for, or be injured by, their selfishness. The ordinary feelings of parent or husband are too often overruled by the consuming passion; the wonted consideration for those who used to be dear to them has given way to an inordinate egotism. Not uncommonly, indeed, there is developed a vein of devilish mischievousness which delights in injuring those whom they ought to protect—a sort of malice, closely resembling the viciousness of certain animals. Of course, all drunkards are not exactly alike; the ruin still preserves the general outline of the primitive structure.

These statements may seem to some to be unnecessary as being already too well known, and too notorious to need any reference to them. But it is just because they are so well known and so indisputable that they are adduced here. Having thus laid firmly down the well-marked consequences of persistent alcoholic excess, it is possible to proceed to consider the less pronounced conditions, and to trace the course of the downward progress. It is evident that there must be many intermediate stages betwixt the commencement and the end of such a course—that some of the deteriorating effects of alcohol must be experienced long before the final stage is reached.

It may be well to speak in general terms of the indication of this direction, of this retrograding and degenerative process. The best subjects for the study of the social effects of alcoholic excess are furnished by the humbler classes: firstly, because the effects are more palpable among them with their limited resources, where excess in one direction means deprivation in another; and, secondly, because they present fewer complications, fewer elements of error to be encountered, than is the case in the more complex condition of affluence. It must not, however, for one moment be assumed that the evil consequences of alcoholic excess are confined to the humbler classes. No position in life will secure the individual against the unpleasant consequences of such self-indulgence, or prevent his reaping as he has sown.

A momentary digression may be permissible at this point; it will help to illustrate what is to be said shortly. In an elaborate paper on alcohol, read before the Medical Society of London last winter, by Dr. Lauder Brunton, F. R. S., to which was awarded the society's medal, it was stated that the first effects of alcohol are felt in the higher or controlling portions of the brain. The consequences are, that the lower or animal impulses manifest themselves, freed from the control to which they are ordinarily subject. Such are the first symptoms of intoxication, after the stage of exhilaration has been passed. Then the motor centres are implicated; and complex movements, like walking, ordinarily habitual, require a conscious effort for their execution, and even then the performance is imperfect. After this the lower portions at the base of the brain are involved, leaving nothing but the respiration and the circulation in action; while still further intoxication arrests these movements, and the organism perishes.

It is this effect upon the higher centres of the brain which induces the most disastrous social outcomes of alcoholic indulgence. The person who takes alcohol to excess becomes a lower form of being by comparison with those around him. This is seen alike in the individual and in the aggregate. There is a diminution so brought about in the power to exercise self-control, and to estimate aright the claims of the future upon the present; there is produced a state of thriftlessness and recklessness, and a lack of consideration for others. These effects are demonstrated distinctly in two out of many practices. The one is that form of improvident self-indulgence—early and premature marriage, where the rite is robbed of all sacredness, and degraded to a mere form of license for unrestrained indulgence. This is common in the pit districts of Durham, where comparative children present themselves to be married, who can scarcely have realized the gravity of the step they are taking. Another form, sadly too common, is that of living in any hovel where the rent is small, so that a larger sum weekly remains over to be spent in drink. This is especially found amid the Irish in towns. The moral effects of decent houses, with sufficient sleeping accommodation for the two sexes, are well known; the disastrous immoral effects of huddling different sexes and ages together, from want of proper sleeping-space, are equally notorious. Not only are these evil consequences of such overcrowding produced, but, when alcohol gives the rein to the passions, these consequences are aggravated and intensified. There are then blended the direct and the indirect outcomes of alcoholic excess, each of which aggravates and adds to the other.

It is unnecessary to multiply illustrations of the deterioration of character induced by alcoholic indulgence. Just one more may be adduced. When recently on a visit to the South Yorkshire Asylum, near Sheffield, Dr. Mitchell, its accomplished superintendent, informed me that even in the victims of mania and general paralysis there was a marked contrast in the degree of violence manifested betwixt the pa-

tients arriving from the purely agricultural districts and those from the iron-work and colliery districts. This he attributed partly to their rougher ways and to the nature of their occupations, but still more to the drinking habits of the latter. That these last formed the chief factor in the production of the result was rendered probable by the large proportion of female subjects of general paralysis in that asylum. This disease is comparatively rare among women ; and its prevalence among females from these districts Dr. Mitchell attributed to the habits of the women being allied to those of the men, especially as regards indulgence in drink.

Such, then, are some of the grave social outcomes of systematic indulgence in alcohol which arrest our attention. We have seen that its effects upon the nervous system are such as to give the rein to the lower centres, chiefly by lessening the control exercised by the higher and restraining portions of the brain. Man escapes from his wonted self-restraint when under the influence of alcohol, and stands before us with his fundamental character revealed. The groundwork of his character is exposed by the removal of the demeanor which he has carefully cultivated. The outside cover is withdrawn ; all, or nearly all, that self-education or cultivation has given, is temporarily taken away. Through the revelations so made by alcohol we not rarely find that even in staid and proper men the tiger and the ape have not entirely died out. The animal propensities are thus discovered to have been concealed rather than subdued. For the time being the intoxicated individual is reft of much that not only he but his ancestors for generations back have studiously cultivated. For the time being he is a lower type of man. About the truth of this statement there can be no doubt.

The progress of physiological psychology, of the investigation of the workings of the mind, has taught us, in unmistakable accents, the strong tendency which exists for a habit to be formed by repetition of anything. After a thing has been done several times it becomes exceedingly easy to do it again. There is, in fact, in the nervous system a great readiness to take on an attitude which has been assumed before. We all recognize how it becomes necessary for every one to rehearse a part before acting it, and how quickly a species of habit or imitative attitude is formed. It is widely recognized that practice makes perfect, and that what was once difficult becomes easy by repetition of it. These are but illustrations of a law universally acknowledged. We all know how important it is to avoid what may become a habit. Consequently, we can see distinctly and with painful clearness that repeated indulgence in alcoholic stimulation, not necessarily extending to visible intoxication, must tend, by virtue of this law, to modify and mould the character. Under alcohol the individual becomes sanguine, reckless, careless of consequences, boastful, and indisposed to sober calculation ; he also becomes self-assertive, arrogant, and boisterous ; there exist a certain impulsiveness and impatience of control, and a distinct

tendency to reach certain ends by violence, if other measures do not seem likely to be successful. In fact, we see the habitual self-restraint slowly developed by the exertions of many ancestors, by the efforts of the individual himself, aided by the training given by education, for the time being withdrawn to a great extent. Every time this act is repeated the greater the tendency for the character to manifest its lower rather than its higher forms. The character is indeed being slowly modified, and that, too, in a most undesirable direction. It is being gradually deprived of much that a slow process of civilization has given it.

It must be patent to all that the direction just depicted is that in which our town populations are distinctly moving. I have sketched elsewhere (the *Alliance News*, July 22 and 29, 1876) those circumstances in the condition of the masses which, in my opinion, render something more than the mere removal of temptation necessary in the practical treatment of intemperance. Whatever may be the effect of monotonous occupations, of bad hygienic surroundings, of improper food in infancy, and the physical deterioration which results from large aggregations of individuals, there can be no question but that repeated alcoholic indulgence is gradually modifying the character of the masses. It is seen in the growing insubordination, in the turbulence, the impatience of control, in the tendency to assert their opinion on subjects of which they are not in a position to judge; it is demonstrated in the growing thriftlessness, in the marked inclination to increase the number of their holidays, in the spending of a large portion of their weekly earnings on Saturdays and Sundays, till the middle of the week is a time of comparative destitution. It is illustrated by the columns of our daily press in the increased acts of violence perpetrated under the influence of alcohol by men accustomed to be intoxicated; and by the increase of disease of the nervous system, especially excitable forms of mania, found most commonly amid the population of certain industrial districts. Doubtless there are many thrifty, sober, self-respecting, and industrious working-men; but it cannot be denied that the proportion of such men to the whole body is less now than it was in days not far gone by. The character of the masses has been undergoing grave modifications in recent times; and the fashioning hand of alcohol can be clearly traced in the production of the results.

There is, however, a still grimmer aspect of this subject than even the effects of repeated indulgence upon the mental attitude of the individual himself, and that is the influence which such indulgence will and must exercise upon the nervous system of his offspring. We are all of us "the outcome of the coöperation of countless ancestral forces," and each of us is individually indebted to his ancestors for every act of self-restraint, every act of self-denial or control exercised by each of them. Our forefathers, in forming their own character, were insensibly fashioning ours. "The fathers have eaten sour grapes, and the chil-

dren's teeth are set on edge," is sternly true. What, then, can we legitimately expect to be manifested in the next generation? Further, if children are taught to frequent taverns, and drink there on holidays and Sundays, by their fond but foolish parents, what effect must this exert upon the character during the plastic period of youth and growth? How far are the inherited mental constitution and nervous system, already depraved to start with, still further modified by such experience of the individual in childhood, when "wax to receive but marble to retain?" Conditions already hard enough upon the child are aggravated by indiscretions perpetrated toward the infant before its own free will and choice can be called into play, before it is responsible for its own actions. Not only have its parents given it an imperfect organization, but they are prejudicing its chances of self-evolution before it has had an opportunity of forming its own decision—it is handicapped alike by descent and by mischievous early training.

The habit of frequenting taverns, of drinking, and of feeling the self-satisfaction so induced, leads to still further indulgence in alcohol by half-grown youths; and so the inherited character is still further deteriorated. The increasing loss of self-control leaves such beings less and less capable of resisting the temptations, the allurements of the public-house. The impulsive and less perfectly controlled nervous system craves more and more for the alcoholic stimulant; and the longings are intensified accordingly. The repeated visits to the tavern grow into a custom, and what commences as an irregular practice becomes crystallized into a habit.

Nor is it in youths alone that the drinking customs of the day are seen in their evil and sombre aspects. The number of respectable girls seen now at public bars is a contrast to what obtained but a few years ago. Up to a recent period, if a girl were known to frequent taverns, her character was gone; and it was rarely that a well-conducted girl was seen in a public-house, and then only with her sweetheart or some male relatives. But now it is sadly different. From familiarity with bars as an outcome of excursions, and even more from the associations of the music-hall, girls, capable of better things, are not now apparently conscious of any impropriety in being in a public-house without male friends; and the painful spectacle of seeing young girls under twenty treating each other at a public bar is a sadly too common occurrence. How can a girl, with the mobile nervous system of her sex, be fitted to be a mother, and to counteract the evil tendencies of alcoholic indulgence in the father, if she herself have been subjected to the same influence? With the facts of inheritance before us, what may we expect, what must we apprehend as to the condition—the future prospects—of the generation following immediately after this one? As our forefathers insensibly and unconsciously built up the character of the present generation, so it, in its turn, is fashioning the character of its successors, its unborn offspring. No wonder, then, that the *morale* as

well as the *physique* of the masses in large towns is undergoing already retrograde changes; and that the present condition fills the minds of observers of social progress with gloomy forebodings as to the future. The progress of civilization has endowed us with a measure of self-control, has tended to subordinate the unit of the mass—to encourage the evolution of the citizen as compared to the mere individual. The effect of alcoholic indulgence to excess is to institute retrogressive changes, and to undo, to a great extent, what civilization has slowly achieved.—*Sanitary Record.*

SKETCH OF GUSTAV WALLIS.

GUSTAV WALLIS, the indefatigable traveler and botanist, whose death at Cuenca, Ecuador, we recently announced, was born May 1, 1830, at Lüneburg, Prussia, where his father was an advocate and proctor of the superior court. He died at the early age of forty-eight years, of which the last eighteen were spent in incessant travel and research. We have not been able to learn any particulars concerning the early life of this distinguished traveler, for the compilers of biographical dictionaries have utterly ignored the man whose merit is simply that he has enriched horticulture with no less than one thousand new species. And here we may remark that works of the class just named are as a rule singularly neglectful of the representatives of science: while every divine and politician that rises ever so little above the average of his class is mentioned, scientific men whose fame is world-wide are passed by in silence. For the biographical items contained in the present sketch we gratefully acknowledge our indebtedness to our German contemporary, *Die Natur*, in which is published a brief but appreciative memoir of Wallis by his friend Dr. Karl Müller, editor of that very able magazine.

Wallis's travels in quest of botanical rarities began in 1860, his first field of labor being the same which, with the exception of two years, engaged his attention down to the day of his death—tropical America. In that year we find him exploring the banks of the Lower Amazon and a few of its principal tributaries, the Tapajos, Madeira, Purus, etc. In 1863, quitting the course of the great stream, he made an excursion northward, crossing the Rio Negro and the Rio Branco and penetrating to the Sierra Parima on the southern frontier of Venezuela, in longitude west 64°, and nearly under the equator. Returning to the Amazon, he explored the left bank for some distance up-stream; then swimming across the river, he followed the right bank westward into Peru and Ecuador, crossing the Cordilleras, and in 1866 arriving at the city of Guayaquil. Here he took ship for the port of Buenaventura in the

Colombian State of the same name; and thence, after exploring the coast Cordillera of the State of Choco, visited the valley of the Cauca. In 1867 he reached Panama and explored the Isthmus up to the volcano of Chiriqui. Turning back he traveled along the northern coast of Colombia till he reached the State of Santa Marta, and then turning south he crossed the Sierra Nevada, and made his way to Santa Fé de Bogotá, traversing the intermediate provinces. In the same year (1868) he sailed on his return voyage to Europe, having traversed the whole extent of tropical America from north to south. He reached his German home in a state of complete physical exhaustion, as very plainly appears from the photograph taken at this time, of which our engraving is a copy.

Hitherto he had been in the employ of a well-known horticultural establishment in Brussels, that of Linden; but in 1869 he received a commission from the London house of Veitch & Co. to visit the Philippines on an errand similar to that from which he had so recently returned. He accordingly took passage for the United States, traveled overland to California, and thence reached Manila by way of China and Japan. He specially studied the mountain-chains of Luzon for plants and other natural-history specimens. In 1871 he returned home by way of Singapore and the Suez Canal.

Before the year was at an end he was again *en route* for the tropical regions of South America. These countries had cast their spell upon him, and he could with justice say that, of all botanical travelers, he knew them best. At the same time he was in hopes that he might be able to visit and botanically explore a region that was in bad repute, owing to the hostile character of the neighboring Indians, viz., the "Pongo de Manseriche"—the grand rocky chasm through which the Marañon forces its way. He had once before approached very near to this locality from the Ecuador side, but had been obliged to give it a wide berth, the natives manifesting their hostility. But his explorations this time extended only to the Paramó country in New Granada, and in 1872 he went back to Europe. This expedition was made at the expense of the house of Linden. Again he explored the elevated mountain-chains of the United States of Colombia; and finally, at his own charges, he began an exploration of the Pacific coast of Ecuador.

The hardships endured by Wallis during these fifteen years of constant pioneering in tropical forests and swamps finally undermined his strength, and he was seized with a complication of diseases. He died, penniless and friendless, in the hospital of the Sisters of Charity at Cuenca, Ecuador, on the 20th of June, 1878.

CORRESPONDENCE.

IS YELLOW FEVER ENDEMIC IN THE GULF STATES?

To the Editors of the Popular Science Monthly.

GENTLEMEN: Mr. L. C. Fisher, of Galveston, Texas, has seen fit, in a recent pamphlet,[1] to attack my article on "Yellow Fever," published in the October number of your valuable magazine, with considerable warmth and even asperity. He considers himself aggrieved by the statement that yellow fever is endemic in the cities of the Gulf and South Atlantic coast. If the gentleman wishes to enter into a controversy on the subject, I must certainly decline to meet him, for two reasons: first, because your space is too valuable for interminable discussions; and, second, it is a matter of general experience that arguments on professional questions with non-professional persons are very unsatisfactory. A few explanatory words, however, I may be allowed to say, and further than this I shall decline to discuss medical questions with a layman.

He says, "If it is only endemic in the Gulf and South Atlantic cities, will Dr. Tracy explain why the disease appeared in Boston and Philadelphia so many years before it appeared in New Orleans?" The answer is a simple one. It was brought to the Northern cities earlier because of their earlier commercial relations with the West Indies, and the difference in the two cases is, that the disease never appears in the Northern cities unless it is imported, while in New Orleans it has never left the city since it was first brought there. New Orleans was exempt up to 1796, but, according to Dr. J. C. Nott, "from that time to the present (1870) there has never been a single year without sporadic cases when they escaped epidemics." Mr. Fisher appears to have the idea that a disease cannot be called endemic excepting where it originates *de novo*, like the malarial poison, for instance. In this sense it cannot be proved that yellow fever is endemic anywhere; for, however it may have first started, it is now the accepted belief that it only occurs as a result of previous cases, and it is fairly said to be endemic in places where the poison does not appear to have ever been destroyed since it was first brought to them. The occasional dormancy of the disease does not imply its extinction, for there is no place in the world where it rages as an epidemic the year round.

[1] "Yellow Fever's Origin. The Disease not Endemic in this Country." By L. C. Fisher. Galveston, Texas.

Mr. Fisher is also perturbed in spirit because I spoke of yellow fever as "beginning its march" and "following water-courses and lines of ocean-travel." He thinks a metaphor out of place in a scientific article, and suggests that "a truly scientific physician would say yellow fever, or its germs or fomites, is carried," etc. The use of metaphor is of course a matter of taste. He does not like it. I do. And that is the end of it. But when he attributes to the "truly scientific physician" such an expression as the fomites of yellow fever, he shows that he is getting out of his depth. Let him look up the word fomites and see what it means.

His suggestion that my unpretending article was the result of a deep-laid plot to ruin the commerce of Southern cities is really too funny for sober consideration. Why did he not go a little further, and accuse me of ulterior designs on the throne of Mexico?

I am sure I should be the last to wish to injure the prospects of any section of our country, and if the present efforts to establish a national quarantine should be successful, and the disease should actually be exterminated in our Southern cities, I should be very much gratified. But, until that is accomplished, I may surely be allowed to have my own opinion on a question on which opinions are, and always have been, so much divided, and to believe that quarantine alone will not banish yellow fever from our Gulf cities at least. Mr. Fisher's energy and earnestness in the matter are to be highly commended, however, and I certainly shall not try to put any obstacles in his way, however much I may disagree with his theories. Yours, very respectfully,

ROGER S. TRACY.

NEW YORK, *November* 18, 1878.

SCIENCE LECTURES IN JAPAN.

To the Editor of the Popular Science Monthly.

MY DEAR PROFESSOR: How I wish you were here to see the eager way in which an audience of intelligent Japanese listen to lectures from their own countrymen and from a few of us who have been fortunate enough to be invited to address them!

I have just finished a course of four lectures on Darwinism. Mr. Kikuchi, a native professor in the university, and a graduate of Cambridge, England, and a wran-

gler besides, interpreted for me. I had my blackboard and chalk, and did my best to make the principles of natural selection clear. As soon as I can write them out they will be published in Japanese, with illustrations, which I shall draw as far as possible from Japanese animals. Prof. Penollosa, one of the new foreign professors at the university, follows with a course of four lectures on the evolution of religions.

It seems such a delight to these people to find that there are some other views held abroad besides those taught by the missionaries, and the hearty way in which they applaud shows how welcome rational views are.

Prof. Mendenhall, of the university, formerly of the Ohio State University, will give a course of lectures on the magnet, capillarity, gravitation, and other subjects, before the same audience—Mr. Agee, the originator of the course, interpreting for him. All the money raised in this way will be devoted to building a lecture-hall in Tokio.

At present the lectures are given in a large tea-house on Sunday afternoons—the large audience seated in the usual Japanese fashion on the floor, with boxes of hot coals here and there for the convenience of pipe-smokers. The audience have presented to them from four to five lectures succeeding each other, with but a few minutes' intermission between each lecturer. Their endurance in this respect is remarkable. I hope to lecture for them repeatedly during the winter.

Faithfully yours,

EDWARD S. MORSE.

TOKIO, *November* 10, 1878.

EDITOR'S TABLE.

PROTECTION AND SOCIALISM.

THOSE who study the influence of legislation in a careful, dispassionate way, and merely as a problem of science, will soon be struck by two things: first, that laws frequently fail to produce their expected effects; and, second, that they give rise to many results which were not at all anticipated. There are various reasons for this; among which are the intrinsic difficulties of a complex subject, false notions in regard to it, and the arrant incapacity of the men who deal with it. In the first place, human society is regulated by laws of its own, which cannot be suspended in their operation by civil interference, and which are, moreover, highly complicated and often obscure and unresolved. And when to the complexities which belong to each locality there are superadded the diversified conditions — climatic, industrial, and racial — which pertain to a vast region of country, the complication of social forces is vastly augmented. Even the most powerful minds, after long application to the subject, are unable to grasp these multifarious conditions so as to know how laws will take effect. Hence the ablest thinkers on social matters are the most cautious, and have least confidence in the production of social good by legislative projects.

But even in those cases that are sufficiently understood to make knowledge valuable for the law-maker's guidance, it is difficult to get the actual benefit of it. Our "legislative wisdom" is too apt to be swamped in legislative folly. There are prevalent superstitions about the dignity, and grand offices, and mysterious potencies of government, which lead people enormously to exaggerate what can really be got out of it. Stripped of this glamour, what is popular government at any time but the office-holding politicians that have been got together to represent and embody it? Constitutions and laws derive their value and virtue from the competency and character of the men chosen to interpret and apply them. If these are low, legislation will be degraded. What government is and does is determined by the quality of those who carry it on. The American Congress is invested with power to abolish past legislation and substitute new legislation;

but who will pretend that it is constituted of men capable of comprehending even the rudimental interactions of social forces, much less the far-reaching consequences of experimental legislation? A large number of them are illiterate blockheads, who have never seriously studied anything—men who have made money and used it to get office. Many Congressmen are mere practised political bullies and intriguers. Many are shrewd lawyers who know the technicalities of their profession, and but little else. Others are educated men, but in whose education no science of any sort ever entered. And there are a few Congressmen of able minds, who have critically studied the facts and principles relating to human society which should underlie sound legislation. But they are precious few; their chances of getting into Congress are slender, and of remaining there next to impossible—even if their self-respect would permit them to wish it. And what chance would really profound men have of influence upon the congressional body? He who speaks of distant results, and the indirect operation of measures, is pooh-poohed as an abstractionist and an impracticable. The statesman is the man of far-sighted forecast, who can act with a reference to remote results; the politician recognizes only that which is direct, immediate, and palpable, such as foolish constituencies can appreciate, and of such is our national Congress mainly made up. If a man of mental grasp and force should undertake to discuss questions of social interest from the scientific point of view, he would not be understood, could not be followed, and would be voted a bore by the majority of mediocrities in the assemblage. Hence the neglect of those remote but often potent consequences of legislation of which short-sighted partisans are apt to take but little account.

An illustration of this is furnished by the long congressional treatment of the subject of "protection." The protective policy has always been defended and urged on the lowest grounds of immediate, palpable, pecuniary advantage, such as unthinking and sordid people can best appreciate. How such legislation will affect this or that business, or operate in this or that locality, has ever been the vital consideration that has obscured all other considerations. What is to be the ultimate outcome of protective legislation in its wide, indirect, subtile influence upon the minds of the people is a question which our national law-makers have not troubled themselves to investigate. Yet agencies that act quietly and take time to develop are often the most momentous at last. Congress has been busy with inquiries as to how tariffs would affect trade and manufactures, but it has had no concern about the habits of thought that the protective system might finally engender among the people. Yet we now begin to be confronted with this serious question. That there is a tendency to the spread of socialistic and communistic doctrines in this country is undeniable; and it is equally certain that the fact inspires grave anxiety on the part of thoughtful and conservative men. Notwithstanding our popular educational system, our numerous colleges, our abundant newspapers and cheap books—unparalleled agencies for the diffusion of intelligence—doctrines are making headway, and are extensively accepted, that threaten the entire subversion of our social fabric. It has not needed much acuteness to connect communistic tendencies with the system of paternal care-taking and protective government which has been growing in strength in this republic for many years. But an English writer of ability on economical questions has lately presented this matter in a way that will command the attention of reflecting people. Prof. Fawcett, who occupies the chair of Political Economy in the University of

Cambridge, and is besides an author on economical subjects, and a member of the House of Commons, has published an article in the *Fortnightly Review*,[1] "On the Recent Development of Socialism in Germany and the United States." He takes the ground that this development is but the natural result of the doctrine of unlimited state functions, and the extravagant notions of what government is capable of accomplishing, which are widely disseminated in both of these countries. In Germany, paternal government, centralization, bureaucracy, and compulsory military service, all conspire to fix deep in the national mind the idea of the omnipotence of the state, which has therefore only to exert its power and it can confer boundless good upon all its subjects. In this country governmental care-taking is most conspicuous in that protective system by which the people's industries are taken charge of by the state. The notion is thus fostered that the people owe their prosperity to the Government, and from this the inference is ready that the state is responsible for their prosperity. But the logic of protection does not stop with its application to business; if it can help people materially it can also help them mentally, and so the belief is now widely maintained that the state *owes* every citizen an education. With so much conceded, the socialist has no difficulty in drawing still further conclusions in the same direction, and so he plants himself at last on the high protective ground that Government shall take possession of all property and take care of everybody. After a careful survey of the claims of socialists and communists as shown by their works, and the proceedings of their Congresses, Prof. Fawcett sums up their programme in the following propositions:

"1. That there should be no private property, and that no one should be permitted to acquire property by inheritance. That all should be compelled to labor, no one having a right to live without labor.

"2. The nationalization of the land, and of the other instruments of production; or, in other words, the state should own all the land, capital, machinery—in fact, everything which constitutes the industrial plant of a country, in order that every industry may be carried on by the state."

The essence of socialism is thus the subversion of private independence and the substitution for it of entire dependence upon the state; that is, the protection of the citizen is to be no half-way matter, but thorough-going and complete. Carried to this conclusion, the doctrine is of course palpably absurd and insane, but have the people not been actually educated toward it by the established and extending doctrine of state omnipotence and protective guardianship of the people's business interests? It is now demanded that the state shall be simply consistent, and carry out its policy. The state has already far transcended its legitimate function of protecting the rights of its citizens by the enforcement of justice in social relations. It has, in fact, neglected and half forgotten this legitimate and incumbent duty in its zeal to take care of those interests and affairs of citizens with which it has no concern, because they are parts of the liberty and responsibility of individuals in free society. Yet this meddling policy of Government is undoubtedly strengthening, notwithstanding its multiform evils. We are boastfully told that the protective system is not declining in this country, as is evinced by the fact that fourteen hundred articles of commerce are the subjects of protective taxation, so that the prices of almost every purchasable thing are dependent upon legislation, while the people acquiesce in the policy as wise and proper. But this is only so much vantage-ground for the communist who demands the enlargement of the system on the basis of its

[1] Reprinted in THE POPULAR SCIENCE MONTHLY SUPPLEMENT for December.

acknowledged benefits. As Prof. Fawcett justly remarks:

"Each fresh extension of the principles of centralization or of industrial protection may be regarded as directly promoting the growth of socialistic ideas. A people who from their earliest childhood are accustomed to believe that state management is better than individual effort, will not unnaturally think that, if they can place themselves in a position to control the state, they will then possess a power which will enable them to redress every grievance from which they are suffering, and to remedy everything which they may regard as unsatisfactory in their condition."

No doubt these radical communistic claims are too wild and ridiculous to be entertained by intelligent and sober-minded people, but many people are neither intelligent nor sober-minded. There is of course no danger that their programme will be carried out, but grave mischief cannot fail to result from the diffusion of such poisonous and destructive notions, and we are now compelled to consider to what extent Government is not itself chargeable with having fostered and encouraged them. At any rate, the honest advocates of the protective system may be led to consider whether it is not productive of an order of evil consequences not foreseen by the politicians who have maintained it.

THE RELIGIOUS RECOGNITION OF NATURE.

Prof. Joseph Henry was a religious man as well as a man of science. He wrote a brief letter to a friend just before his death, suggesting at its close that it is in the "line of theological speculation;" and being an eminent scientist, his religious views are so prized by religious people that this letter has been printed as a tract for gratuitous distribution, and is to be had at the American Tract Society, 150 Nassau Street, New York. It is an encouraging sign of the times to see devout people showing in this way an increasing appreciation of the importance of the beliefs of scientific men concerning theological matters. We heartily commend this practice, for if theological discords are ever to come to an end it must be by the substitution of scientific ideas for dogmatic creeds. The sects will ultimately harmonize just in proportion as they absorb scientific truth.

Prof. Henry did not live to revise his letter (usually a careful habit with him), and it therefore has the interest and value of a spontaneous private expression of his convictions, and it was made, he says, "without stopping to inquire whether what I have written may be logical or orthodox." With this candid carelessness about his orthodoxy we entirely sympathize, and are here interested in this unconstrained avowal of his religious views because of their relation to science.

In the true scientific spirit and method he begins by looking out upon Nature and regarding it as presenting problems that require to be solved. Largely viewed, we are in the midst of its mighty movement; we are a part of it; we emerge and quickly disappear—what view shall we take of it? on what hypothesis explain it? Among the various theories of the universe he accepts the theistic theory as the "simplest conception," and giving the most satisfactory account of things. His solution is that the order of the world is originated and directed by a Divine Being who has made man with a capacity of understanding the universe by means of science. As his own statement is important, we quote his words:

"We live in a universe of change: nothing remains the same from one moment till another, and each moment of recorded time has its separate history. We are carried on by the ever-changing events in the line of our destiny, and at the end of the year we are always at a considerable distance from the point of its beginning. How short the space between the two cardinal points of an earthly career, the point of birth and that of death; and yet what a universe of wonders are presented to us in our rapid flight

through this space! How small the wisdom obtained by a single life in its passage; and how small the known when compared with the unknown by the accumulation of the millions of lives through the art of printing in hundreds of years!

"How many questions press themselves upon us in these contemplations! Whence come we? Whither are we going? What is our final destiny? What the object of our creation? What mysteries of unfathomable depth environ us on every side! But after all our speculations, and an attempt to grapple with the problem of the universe, the simplest conception which explains and connects the phenomena is that of the existence of one spiritual Being, infinite in wisdom, in power, and all divine perfections; which exists always and everywhere; which has created us with intellectual faculties sufficient in some degree to comprehend his operations as they are developed in Nature by what is called 'science.'"

Prof. Henry here begins with Nature, and deduces from its study the fundamental conception of religion—the idea of a Divine Spiritual Ruler of the universe, who has made man capable of penetrating its secrets and understanding its laws by the faculty of reason applied to scientific investigation. Nature, God, religion, and science, are thus bound together in one grand synthetic and harmonized conception. In this view Prof. Henry represented the most advanced intelligence of his time, and how advanced *was* his view we can best appreciate by contrasting it with other states of mind in the theological sphere.

It is well known that, in the language of a recent writer, "the men of the first Christian generation, including the apostles and the writers of the New Testament, lived in the almost daily expectation of the Lord and the end of the world." The notion of the world's coming to an end was an easy one in a state of perfect ignorance of the nature of the world. When it was supposed to be flat and small, and stationary, and there was no such idea as that of the universe, and not the slightest conception of anything like order and stability in the constitution of sublunary things, there was certainly no reason why the world should not come to an end at almost any time. It was supposed to have been made in a somewhat hurried manner, not very long ago, and it was natural to think that it might terminate at almost any hour in a similar sudden way. And, as its creation was considered as belonging to theology, its extinction, it was supposed, would come by a theological catastrophe. The idea that the world might come to an end was made possible by the ignorance of the time, and as men knew nothing about its shape, magnitude, motions, relations, and antiquity, they could not be expected to know anything in favor of its duration. No blame can therefore be attached to the primitive Christians who were in daily expectation of the end of the world.

But when we pass over a period of eighteen hundred years and reach the nineteenth century, the case is different. It is not surprising that the early traditions should have long been tenaciously held in the sphere of theology, but it certainly is a matter of some amazement that a belief in the predicted destruction of the earth as the sequel of a theological programme could have been seriously entertained so late as the middle of the present century. Yet the sudden ending of mundane affairs in accordance with Scripture predictions was not only profoundly believed by multitudes, but the exact time was assigned and extensive preparations made for the grand event. The epidemic of Millerism spread over large parts of the country not many years ago, and, although the exact calculations were discredited, revised calculations took their place, and societies of "Second Adventists" in different parts of the country have kept alive the exhilarating prospect that the earth would soon be wrapped in conflagration, and, if not reduced to nothing, that the

terrestrial order would at any rate come to an end.

A Second Advent Convention has recently been held in New York, which was devoted to a modified form of this old doctrine. A church was crowded with its adherents, coming from all the religious denominations in various parts of the country, and the subject was discussed for days with great fervor and enthusiasm. Nothing was said in the proceedings about the end of the world, but they were redolent of the expectation of great supernatural events which it was supposed by many may happen at any time. A great array of theological talent was present, and many learned disquisitions were read. The conference was Pre-millenarian in sentiment, and Dr. West, a Presbyterian clergyman of Cincinnati, explained the doctrine as follows: "Christian Chiliasm, or Pre-millenarianism, is the doctrine of the personal reign of Christ one thousand years after beast, false prophet, and apostate Christendom, have been judged and perished in a common doom. It is the doctrine of a visible and external sovereignty of Christ upon earth as the outcome of history, the redeemed church of all ages rejoicing in the fullness of a resurrection-life, in the actual presence of Him who is the 'Prince of the kings of the earth'—a kingdom of outward glory established upon the ruin of the polities of all nations wide as the canopy of heaven."

Furthermore, "Pre-millennialism is a protest against the doctrine of the unbroken evolution of the kingdom of God to absolute perfection on earth apart from the visible and miraculous intervention of Christ. It is an equal protest against that vapid idealism which volatilizes the perfect kingdom into a spiritual abstraction apart from the regenesis of the earth."

What Dr. West here understands by "vapid idealism" and volatilizing the kingdom into a "spiritual abstraction" is simply a protest against the enlarged interpretation of Scripture passages in which many modern theologians are inclined to indulge. The convention went unanimously for the literal meaning of Biblical texts. "Outside of its lids" (the Bible), said Dr. Tyng, Jr., "we decline to follow our disputants." Again: "One verse in every twenty-five or about three hundred verses of the New Testament speak of this future event." Dr. Goodwin planted himself "on the self-sufficiency of the Scriptures to explain themselves." The discussion throughout was filled with theological technicalities, the import of adverbs and pronouns, the rendering of Greek and Hebrew passages, and the ransacking of Biblical books from the Pentateuch to the Apocalypse for hints, allusions, and declarations, that might be made to sustain the hypothesis to which the body was committed.

We refer to all this merely as a curious and instructive phenomenon of our times. There was but one reference, as we observe, to science in all the proceedings. A distinguished clergyman remarked: "Look at that audience; you can't get such a gathering at secular conferences. Why, at a scientific convention a paper an hour long nearly always succeeds in thinning the audience down to the specialists in the topic of which it treats." This observation seems to have exhausted the entire interest of the convocation in scientific matters. All the knowledge that has been developed in the last five hundred years regarding the order of the world was as so much idle wind to these Second Advent theologians. Prof. Henry, as we have seen, began his theology with the consideration of Nature; this conference neither began with Nature nor ended with it, nor made any more reference to it than as if it had been composed of disembodied beings who had never heard of natural things. Though their theories were maintained as taking effect upon

human life and the earthly destiny of humanity, there was not a reference to the natural world as being in its existing order an embodiment of Divine wisdom, or entitled to the slightest serious consideration. In fact, the whole scheme of doctrine put forth was impliedly based upon the old assumption that Nature belongs to Satan, and deserves destruction as the embodiment of all sin. Dr. Brookes, of St. Louis, discussed the doctrine of the convention in relation to the fall of Adam and the universal curse that it entailed, saying, "From that day to this the curse has smitten the old and the young, the rich and the poor, the king and the peasant, the philosopher and the savage alike, and diffused its virulent poison through the whole system of Nature."

It is clear that a great deal is yet to be done before such enlightened opinions as those of Prof. Henry become accepted and assimilated in the religious world; and such conventions as this of the Second Adventists are extremely useful as indicating the amount of conscientious ignorance that has yet to be overcome before the scientific truths of Nature are even so much as recognized.

IMPROVED DOMESTIC ECONOMY.

The Princess Louisa received an address from a deputation of the Ladies' Educational Association of Montreal, and they got from her a very sensible reply. But what will the operators of our fashionable girls' schools and of our female colleges and normal schools say to the closing observation of this royal and court-bred lady, which was as follows: "May I venture to suggest the importance of giving special attention to the subject of domestic economy, which properly lies at the root of the highest life of every true woman?" This is a momentous truth; none the more true, of course, because uttered by a princess, but perhaps some will be induced to reflect upon it on account of the distinguished source from which it comes. For if what the princess here says is correct, our schools for the education of women are very far from what they should be. Domestic economy, in its full significance as a foundation of the highest life of woman, happens to be just the one particular thing which our female boarding-schools, colleges, and normal schools systematically avoid. They learn languages, and history, and algebra, and music, and many other fashionable things, but the science of domestic life and the art of home-making find no place in the feminine scheme of studies. Here and there a little attention is paid to it, but it nowhere has the rank and importance which is rightfully its due, and which this most sensible princess claims for it.

The term "domestic economy" has been hitherto used in so narrow and misleading a sense that there is considerable prejudice in regard to it. Its common implication is a mere improved mechanical housekeeping, or domestic drudgery made methodical, with a chief view to economy in home expenditures. The term has participated in the vulgarity that attaches to the menial and servile associations of the kitchen, so that little books upon domestic economy are thought the proper things to put into the hands of cooks and hireling housekeepers. But domestic economy, as something "which properly lies at the root of the highest life of every true woman," is a very different thing, implying culture and intelligence in the whole circle of home duties and responsibilities, and the consequent renovation and elevation of the domestic sphere. This view happily begins to be more clearly and widely appreciated. We have just read with great interest a lecture on scientific housekeeping delivered by Mrs. Arthur Bate before the Popular Science Society at Milwaukee College, which explains in an admirable

way how many new subjects and questions there are upon which women require to be trained in order to make them competent and skillful administrators of home affairs. Mrs. Bate shows conclusively that science has exactly the same office to perform in guiding domestic art that it has had to perform in giving efficiency to all the other arts, and that it will confer the same interest and dignity upon household affairs that it has already conferred upon other departments of activity. She well observes that in gaining the knowledge necessary to make the home a sanitarium—the house of health—educated housekeepers would do more to emancipate the world from fleshly ills than doctors have ever done or ever can do.

Mrs. Bate makes an important point in showing that the ignorance of women is a fatal hindrance to the introduction of many improvements by which domestic operations could be greatly facilitated, if only housekeepers knew enough to make them available. An illustration of this is just now at hand. The use of gas-stoves for cooking is one of the most important ameliorations that have been conferred upon the kitchen in a long time; but, as that realm is given over to tradition and blind habit, but little advantage has been taken of the improvement. Gas-stock holders are losing their sleep for fear Edison is going to destroy their business, but, if the benefits to be gained by the consumption of gas in cooking were generally understood, there would be but little occasion to fear from a diminished consumption of the article. A lady trained in the South Kensington Cooking-School, and who has taught in the Culinary College of Edinburgh, has recently come to this country and given a course of demonstrative lessons in cookery in New York. Her mode of working has been a sort of new revelation to the large class of ladies which has attended her instructions. Cooking has hitherto been associated with dingy kitchens and fiery ranges that evoked the free perspiration of the attendant; but Miss Dods uses a gas-stove, and does her work so neatly that it might be carried on in a parlor. In the dozen lessons she gave, scores of dishes of all kinds were prepared rapidly by the use of gas, and that they were well made was sufficiently evinced by the eagerness of the ladies to purchase them at the close of each lecture. To a curious inquirer she said, that in her practical demonstrations she had cooked by gas alone for years in preparing hundreds of dishes of a great variety in teaching. This is but one example, of which many might be cited, showing how people suffer in their domestic life because women are not properly instructed in the principles of practical household art, and in the resources that might be commanded for its improvement.

LITERARY NOTICES.

The Bible of To-day: A Course of Lectures by Rev. John W. Chadwick. New York: G. P. Putnam's Sons. Pp. 304. Price, $1.50.

On a subject of profound interest throughout Christendom, and upon which there is great discordance of opinion, coupled with intense feeling, Mr. Chadwick has produced an independent and instructive work, which is at the same time both reverent and rational.

The more liberal and catholic spirit of modern inquiry is undoubtedly due to the influence of science, which reaches far beyond the field of physical experiment. The attacks upon the Bible by the skeptics of the last century were made in the spirit of the age, which was polemical and disputatious, as it had been from the middle ages. Discussion was filled with the irritations, acerbities, bitterness, and the rancors of personal controversy. The Bible was argued over much like a party at the bar of our courts by the lawyers, one of whom wishes to set him free and the other to get him hanged. The Bible was attacked, as it was

defended, and in spirit the skeptics were as much theologians as their opponents. But science has very much changed all this, and what was long an exasperating controversy is now becoming a quiet and rational investigation. While in the disputatious era it was maintained, on the one side, that the Bible is an exceptional and supernatural book—the plenary inspiration of God, and all its parts perfect and infallible—on the other hand, it was asserted to be a fabrication and an imposture. We have now pretty much passed out of that phase, and entered into the phase of calm and critical inquiry as to the origin and history of the various books which appeared at different times, and were at length collected to form the Christian Scriptures. The inquiry should be candid and dispassionate, but conducted with inexorable reference simply to the establishment of truth.

Much has been done in recent years, by scholars of various countries, to throw light on the historic origin of the Biblical books, and Mr. Chadwick has done the public an invaluable service in presenting, in a compendious form, the main results of this most interesting research. Of his treatment of the subject the author says:

"My object is to condense into a single volume, modest in size and cost, the principal results of the best historical and scientific criticism of the separate books of the Bible, and of their mutual relations. I am not aware of any other volume which has made exactly this attempt, and it is high time that somebody should make it. The truth of these results, if truth it be, is scattered up and down through scores of volumes, which few public libraries, even in our great cities, have upon their shelves, and which it would cost the individual reader hundreds of dollars to procure. Nevertheless, I shall be disappointed if one effect of these lectures is not to impel the reader to procure for himself some of the books which I have found most helpful and inspiring. Much, however, that has been written is not only costly and inaccessible, but is so laboriously and minutely critical in its form as to repel the average reader. I dare not hope that my own treatment will be entertaining, but for busy men and women I trust it will have some advantage over that of the great Biblical scholars in that it is at once compact and comprehensive."

Mr. Chadwick's volume consists of eight lectures, which were first delivered to his own people in Brooklyn—four on the Old Testament, one on the Apocrypha, and three on the New Testament. The first is on the Prophets, and is preceded by a brief history of the Old Testament canon. The arrangement of the lectures is intended to be simply chronological, and the prophets are considered first because it was evidently Mr. Chadwick's idea that, with some inconsiderable exceptions, we have in the prophets the earliest writers of the Old Testament. The Histories are next considered, because these are believed to have been written, for the most part, before the "Law."

The "Psalms and other writings" come last, as being written after the "Law." The Prophets are first taken in the order of our common version, and the date and authorship and character of each discussed. An inquiry is instituted as to the nature of prophetism, and reasons are assigned for the belief that the early prophets were not monotheists; the writing prophets of the eighth century B. C. being probably the first monotheists.

In his lecture on the Histories Mr. Chadwick finds them not to be histories in the ordinary sense of the word, but didactic compositions. In his lecture on the Pentateuch Mr. Chadwick considers it as a stratified series. The oldest or bottom layer, richest in narration, is a prophetic one, dating from the eighth century before Christ. The next layer he designates as priestly-prophetic, and which includes the whole of Deuteronomy. Its date is fixed at 621 B. C. The next and topmost layer is altogether priestly, and includes all of Leviticus, a good deal of Numbers, and much besides. This upper stratum is what critics call the *Book of Origins*, and its date is the crucial question of Old Testament criticism. And Mr. Chadwick, following Kuenen, assigns it to the fifth century B. C., and 800 years after the time of Moses. By this mode of treatment he apprehends the entire history of Israel as an evolution from a simple to a complex worship, from the spontaneity of prophetism to fixity and formalism, from fetichism and Nature-worship up through monolatry to monotheism.

In the fourth lecture these principles are applied to the Psalms and other writings. In regard to the Psalms, Proverbs, Ecclesiastes, etc., the old interpretations are

thoroughly traversed. The Song of Songs is characterized as a very noble poem, and the earliest complete book in the Old Testament, its date being about 800 B. C.

The Apocrypha is treated as the "missing link" between the New Testament and the Old. The apocryphal literature goes a great way, and shows how gradual was the evolution from Malachi to Jesus. The book of Enoch, which only the Abyssinian canon has retained, is further evidence of this, and is of the first importance. We are now already in the New Testament atmosphere, especially in that of the Apocalypse.

The sixth lecture, after a brief history of the formation of the New Testament, proceeds to consider the Epistles. Of the fourteen commonly ascribed to Paul only eight are found to be authentic—Romans, Galatians, and Corinthians, surely so; the others not so certainly. From Thessalonians and Philippians we have the evolution of Paul's ideal Christ from simple manhood to superangelic power and grace.

In the seventh lecture the Apocalypse is assigned to the year 69 B. C. The last lecture is on the Four Gospels, and Matthew is assigned to the year 100 A. D.; Luke to 115 A. D.; Mark to 120 A. D.; and John to 140 A. D.; these dates are, however, only approximate. A full chronological table, setting forth the dates of all the separate books of the Bible, is prefixed to the volume, in the shape of an analytical index.

This book represents a great amount of labor and research, and is executed in a manner highly creditable to the scholarship of the author. Though following the great authorities that have preceded him, he is not a servile follower but an independent student. The style of the work is spirited and attractive, and it is inspired with a moral earnestness and a reverent sincerity that will commend it to all unprejudiced and fair-minded readers.

Stock-Breeding: A Practical Treatise on the Application of the Laws of Development and Heredity to the Improvement and Breeding of Domestic Animals. By Manly Miles, M. D., late Professor of Agriculture in the Michigan State Agricultural College. D. Appleton & Co. Pp. 424. Price $1.50.

We have here a timely and valuable manual upon a subject the practical importance of which is only equaled by its theoretical interest. A well-digested treatise on the art of cultivating animals through the control of genetic conditions has been long needed. Upon this point the author justly observes, "It is somewhat remarkable, in this book-making age, that there is no systematic work accessible to the student in which the known facts and principles of the art of improving and breeding domestic animals are presented, in convenient form, for study and reference, notwithstanding the importance of live-stock to the farmer, and the wonderful progress that has been made in its improvement since the time of Bakewell." The art of breeding was long pursued empirically, and was developed by numberless experiments from which rules were deduced that, though not rationally understood, were still sufficient to guide breeders in the improvement of stock. Modern biology has given greater precision to observations, has indicated new lines of experimental research, and has established various principles that are of controlling utility in practice. Much is still unsettled, and many questions remain in profound obscurity, yet there has been such a clearing up of old difficulties and such an extension of positive knowledge in this field that it is now necessary to deal with the subject from the scientific point of view. Dr. Miles's work is rich in the varied facts which constitute the foundation of the art, and which have been selected with careful judgment in regard to their authenticity, but in the classification and interpretation of his data the author follows the scientific method. Indeed, if a book were to be selected simply to illustrate the practical fruitfulness of modern scientific inquiry, in one of its most recent lines of exploration, we are inclined to think the present volume might well be chosen for the purpose. The book is so full of interesting and valuable information that we should like to transfer large portions of it to our columns; but, as this is impossible, we must content ourselves with quoting a few remarks from the author's preface, indicating the main features of his work:

"In a popular exposition of the principles of an art that is almost exclusively based upon the experience of practical men there is little opportunity for originality, aside from the classification and arrangement of facts, and the infer-

ences, in some instances, that may be drawn from them in explaining the practices of the most successful breeders. It is believed that a systematic statement of what is already known in the practice of the art is of greater importance, at the present time, than any new truths, as it must furnish the only consistent foundation for future progress and improvement. The numerous cases that have been collected to illustrate the various topics under discussion have been compiled, as far as possible, from original sources, and presented in their original form—preferences, in nearly all cases, being given to the works from which they are quoted. This feature of the work will be of interest to the student who wishes to study the subject in greater detail, as it will, to some extent, serve as an index to authorities that may be profitably consulted. In the limits of a popular work it is of course impossible to treat each topic exhaustively, and the attempt has been made to present only such an outline of the principles of the art as would be required in a text-book for students, or a work of reference for farmers."

Outlines of Ontological Science; or, A Philosophy of Knowledge and of Being. By Henry N. Day, author of "Psychology," "Logic," "Ethics," etc. New York: G. P. Putnam's Sons. Pp. 441. Price, $1.75.

The present work is an attempt to grapple with the profoundest problems of philosophy by determining the nature and limits of genuine knowledge, and to determine the relations and interdependences of its several parts. The author claims for his book nothing of novelty in its design, but alleges, as a reason for undertaking it, that "the recent rapid developments of science, both mental and physical, with their widely-diversified results, seem to invite a fresh endeavor in this direction, as they furnish new facilities and helps for prosecuting it." As might be expected from the point of view here taken, modern scientific and philosophical ideas are brought under review and estimated, the result being, as we gather from the writer, that fundamental questions of speculative inquiry have not been much disturbed by modern research. In his last chapter on "Cosmogony" the author takes up the doctrine of evolution, which he says is philosophically "mere hypothesis," "irreconcilable with facts claimed to be ascertained by science," "repugnant to reason," and "as a theory of causal agency in the cosmos is a failure."

Life in Other Worlds: including a Brief Statement of the Origin and Progress of Life in our World. By Adam Miller, M. D. With an Appendix of Three Sermons by Rev. H. W. Thomas, D. D. Chicago: Fox, Cole & Co. Pp. 282. Price, $1.50.

A book of multifarious speculations, theological, historical, moral, astronomical, and physical. The author says that it was originally written with no intention of publication, but he got so much comfort out of the contemplations it embodies that he was impelled to print it. He remarks, "With a hope that some one who will read these pages will find encouragement for a union in the great future with friends that have gone before, as well as for an acquaintance with the millions of happy spirits who have passed through the vale of sorrow to their final home, I submit this work to a generous public." Our attention has been especially called to the author's three chapters on "Solar Light and Heat," in which he differs from the ideas that men of science are in the habit of taking. The cause of solar heat he holds to be the refraction of light, and says: "The atmosphere that surrounds our earth is in the form of a concavo-convex lens. The aqueous vapor in the upper regions of the atmosphere is intensely cold, yet, acting on the rays of light like a cold-water lens, produces heat; and here is the secret of solar temperature on the earth, and the change in temperature is caused by the varying angles at which the solar rays strike the atmosphere. I repeat, it cannot be denied that refraction of the rays of light will produce heat. The heat at the focus of a 32-inch lens exceeds almost every kind and intensity of heat known to terrestrial chemistry. Again, it cannot be denied that the earth's atmosphere is a refracting medium, and that as such it is capable of producing heat from rays of light."

The book is printed on tinted paper, and contains a portrait of the author.

Filtration of Potable Water. By Prof. William Ripley Nichols. From Massachusetts Health Reports, 1878. Pp. 90.

The author of this valuable report considers the subject of filtration under the three heads of "Artificial Filtration on the Large

Scale," "Natural Filtration," and "Household Filtration." The two former sections will be read with interest by the civil and sanitary engineer; the last, that on "Household Filtration," directly concerns every family in the land. Too often the quality of water supplied to the inhabitants of our cities is truly described as in the following reply to a letter of inquiry: "When the river is clear we have clear water; when the river is muddy we have muddy water." Such a state of things necessitates the use of domestic filters, many different forms of which are described and criticised by Dr. Nichols.

The Old House altered. By G. C. Mason, Architect. With Illustrations. New York: G. P. Putnam's Sons, 1878. Pp. 185. Price, $2.50.

The problem here considered is one that is every day arising for solution—how to modernize and beautify an old house. In a series of chapters which take the form of familiar letters the author first describes the original form of an old mansion; then details the changes in its internal arrangement and in its exterior, necessitated by the requirements of modern life and of modern culture; finally, he tells us how these changes have been made. Nor does Mr. Mason restrict himself to the consideration of the purely architectural aspects of the problem, for the old mansion had to be transformed not only in itself, but also in its fittings and furniture. There is room for difference of opinion as to the desirability of such transformations, and most persons would perhaps think it the better way to pull down and build anew; but, if regard for an old house interferes to prevent its demolition, our author's plan of transforming and modernizing it will deserve to be considered.

Goethe's Faust. Erster Theil. With Introduction and Notes by James Morgan Hart. New York: G. P. Putnam's Sons, 1878. Pp. 286. Price, $1.25.

The first part of "Faust" forms Vol. IV. of Prof. Hart's series of "German Classics." The English student of German will derive from the editor's very brief grammatical and critical notes, and from his learned introduction, material aid in overcoming the difficulties of the text.

Practical Chemistry for Medical Students. By M. M. Pattison Muir. London and New York: Macmillan & Co., 1878. Pp. 64. Price, 60 cents.

The medical student will here find precisely that measure of information in practical chemistry which is *absolutely indispensable* for him to possess. The author's object is in no wise to "cram" the student for examination-day, but to put him in possession of a few chemical principles, and to familiarize him with certain chemical processes, without which he cannot hope for success in his chosen profession.

The Blessed Bees. By John Allen. New York: G. P. Putnam's Sons, 1878. Pp. 169. Price, $1.

Under this quaint title, Mr. Allen publishes the record of a year's experience and results in bee-keeping. Persons who may be thinking of engaging in that pursuit will doubtless learn much from this little book. Bee-keeping, by modern methods, the author informs us in the preface, is an art just as much as growing wheat or fruit or stock; the profits which may be gained from it are just as certain as the profits from any other branch of rural labor, and are much larger.

The Relative Proportions of the Steam-Engine. By William D. Marks. Philadelphia: Lippincott, 1878. Pp. 161. Price, $1.50.

A long-felt want is here supplied, viz., simple, practical formulæ for the determination of the relative proportions of the component parts of the steam-engine. Rankine appears to be the only author in English who has attempted to do this; but his treatment of the subject is so brief as to be obscure. The present work is therefore a very welcome contribution to the science of the steam-engine.

Flower-Painting. By Mrs. William Duffield. New York: G. P. Putnam's Sons, 1878. Pp. 46. Price, 50 cents.

The fact that this handbook of flower-painting has already passed through twelve editions in England speaks well for its popular character. Like all the volumes of the series of "Art Handbooks" to which it belongs, it is a model of tasteful book-making.

The Railway in its Relation to Public and Private Interests. By Simon Sterne. New York, 1878. Press of the Chamber of Commerce. Pp. 38.

Mr. Sterne advocates governmental control of the railway lines. The cry that this is "centralization" does not frighten him, because "whether centralization is objectionable depends upon whether it is good or bad, and whether it supersedes a better or a worse system." And he quotes with approval the remarks made by Burke: "If I am not able to correct a system of oppression and tyranny that goes to the utter ruin of 30,000,000 of my fellow-creatures, but by some increase of the influence of the crown, I am ready here to declare that I, who have been active to reduce it, shall be as active and strenuous to restore it again. I am no lover of names; I contend for the substance of good and protecting government, let it come from what quarter it will."

Golden Songs of Great Poets. Illustrated by Darley, Moran, Hart, Fredericks, Smillie, and McEntee. New York: Sarah H. Leggett. Price, $5.

Few books have fallen into our hands having a more distinguished paternity than this one. It contains six poems, not elsewhere published, from six of the leading American poets of the century, and its pages are embellished with thirty-six beautiful illustrations, by artists of scarcely inferior rank. Holmes contributes the introduction, "On the Threshold;" Bryant follows with a pleasant bit of Nature entitled "The Song Sparrow;" and Longfellow writes of what he is supposed to know most about, "The Poets." "June on the Merrimac," by Whittier, is a gem well worth the price of the book, and there follows Lowell on "The Fire-Fly," and Bayard Taylor on "The Lost Caryatid." The printer and binder have done their share of the work in befitting style, making the volume, taken altogether, one of the handsomest and most interesting holiday books we have seen.

Geology of Wisconsin. Vol. II. Madison: Published by the Commissioners of Public Printing, 1877. Pp. 797.

Though this volume is numbered II., it is in fact the first of the series in the order of publication, and Vol. I. is yet to follow. The reason of this reversal of the logical sequence is that, while the matter belonging to Vol. II. is completed, that which of right belongs to Vol. I. has to await the completion of the survey. The volume, which, by-the-way, is highly creditable to Wisconsin lithography and typography, consists of four parts, viz.: Part I., containing the annual reports for 1873, 1874, and 1875, now first published. During the two former years, the survey was under the general direction of Dr. Increase A. Lapham, and during the last year under Dr. O. W. Wight. Part II. treats of the geology of Eastern Wisconsin, and is written by the geologist-in-chief, Mr. T. C. Chamberlin. Part III., by Roland D. Irving, treats of the geology of Central Wisconsin. Finally, Part IV., on the "Geology and Topography of the Lead-Region," is by Moses Strong. Accompanying the volume is a set of maps, fourteen in number. Numerous colored and plain lithographic plates and wood-engravings serve to embellish the volume and to illustrate the text.

First Annual Report of the United States Entomological Commission, for the Year 1877, relating to the Rocky Mountain Locust. With Maps and Illustrations. Washington: Government Printing-Office, 1878. Pp. 787.

The vast fund of information acquired by the Entomological Commission during the first year of its labors is in this report laid before the agricultural population of the States and Territories exposed to the locust-plague. The commissioners, Messrs. Riley, Packard, and Thomas, justly congratulate themselves on the success which has attended their efforts to determine certain cardinal points touching the origin and distribution of the Rocky Mountain locust—its breeding-grounds, geographical range, migrations, habits and natural history, the means of checking its ravages, etc. Much, indeed, has been done toward accomplishing the purpose for which the commission was appointed; but still more remains to be done, both in the way of research and, above all, in the way of applying on the large scale the remedies and devices for exterminating the locust which are here explained. "Further surveys need to be made of the permanent breeding-grounds in the Northwestern Territories; more facts are needed to perfect our knowledge of the mi-

grations in this area; the coöperation of our Government with Canada is needed to work up the subject properly in the locust-region north of the United States boundary-line; and some other problems remain to be solved." This done, it is hoped that it will be "possible at least to greatly modify or lessen these invasions, and diminish the losses resulting therefrom, if not entirely prevent them."

Dangers from Color-Blindness in Railroad Employees and Pilots. By B. Joy Jeffries, M. D. Pp. 40. Incurability of Congenital Color-Blindness. Pp. 8. Color-Blindness and its Practical Relations. Pp. 4. Same author. Boston: Rand, Avery & Co. print.

The very title of the first of the above-named publications will win for it the earnest attention of the public. The dangers from the color-blindness of railroad-men and pilots are obvious, and it is time that efficient measures should be taken to obviate them. The Massachusetts Board of Health is to be highly commended for having procured the publication of Dr. Jeffries's observations on this subject.

Elementary Course of Geometrical Drawing. By G. L. Vose. Illustrated by 38 Plates. Boston: Lee & Shepard, 1878. Price, $5.

This course is designed to meet the wants of the lower classes in engineering schools; it will also be of service to those who wish to pursue this branch of study by themselves. The system here followed has been subjected for many years to the test of practical experience in the class of civil engineering in Bowdoin College.

PUBLICATIONS RECEIVED.

Report of the Chief Signal-Officer for the Year 1877. With numerous Charts. Washington: Government Printing-Office. 1877. Pp. 570.

A Face illumined. By E. P. Roe. New York: Dodd, Mead & Co. Pp. 658. $1.50.

Report of the Board of Regents of the Smithsonian Institution for the Year 1877. Washington: Government Printing-Office. 1878. Pp. 500.

The Telegraph in America. By James D. Reid. With numerous Portraits. New York: Derby Brothers. 1878. Pp. 846. $6.

The Races of European Turkey. By Edson L. Clark. New York: Dodd, Mead & Co. 1878. Pp. 538. $3.

Daily Bulletin of Weather-Reports for January, February, and March, 1877. Washington: Government Printing-Office. 1878.

First Quarter Century of the Home Insurance Company. New York: Printed by order of the Board. 1878. Pp. 80.

Astronomy. By R. S. Ball. New York: Holt & Co. 1878. Pp. 167. 60 cents.

Science News. Published fortnightly by S. E. Cassino, Salem, Mass. Vol. I., No. 1. Pp. 16. $2 per annum.

Geological and Natural History Survey of Minnesota. Report for the Year 1877. Minneapolis: Johnson, Smith & Harrison. 1878. Pp. 225.

Third Annual Report of the Johns Hopkins University. Baltimore: Murphy print. 1878.

Annual Report on the Operations of the Department of the Interior for the Year ending June 30, 1878. Washington: Government Printing-Office. Pp. 48.

An Essay on Free Trade. By Richard Hawley. New York: Putnam's Sons. 1878. Pp. 63. 25 cents.

Dissipation of Electricity in Gases. By Demetrieff Boboulieff. From the *American Journal of Science and Arts.* Pp. 13.

Report of the New York Association for improving the Condition of the Poor. Pp. 64.

Laws affecting Tenement and Lodging Houses in New York and Brooklyn. Printed by the Association. Pp. 11.

Constituents of Climate, with Special Reference to Florida. By F. D. Lente, M. D. Louisville, Kentucky: *Richmond and Louisville Medical Journal* print. Pp. 56.

On the Genealogy of Plants. By Lester F. Ward. Pp. 378.

Report of the Survey of the Northern and Northwestern Lakes and the Mississippi River, in Charge of C. B. Comstock and M. H. Adams. Washington: Government Printing-Office. From Report of Chief of Engineers. 1877. Pp. 100.

Catalogue of the *Iron Age* Library. New York: David Williams. Pp. 50.

General Vaccination throughout the Country. By Elisha Harris. Pp. 16. Records of Deaths and Causes of Death. Same author. Pp. 16. From Papers of the American Public Health Association. Cambridge: Riverside press. 1877.

Art Anatomy. By A. J. Howe, M. D. Pp. 23.

Note on Cladocera. By Edward A. Birge, Ph. D. With Plates. Pp. 34.

A Collection from the Ancient Cemetery at the Bay of Chacota, Peru. By John H. Blake. Printed at the Salem press. Pp. 304.

The Halifax Fishery Award. By Alexander Bliss. Washington: Beresford print. 1878. Pp. 24.

American Jurassic Dinosaurs. By O. C. Marsh. With Plates. Reprinted from *American Journal of Science.* Pp. 6.

Evolution of Character. By J. I. D. Hinds. Nashville, Tennessee: Ligon & Co. print. Pp. 11.

Air and Moisture on Shipboard. By T. J. Turner, M. D. Pp. 16.

Chemical Constitution of the Atmosphere. By Albert R. Leeds, Ph. D. From Annals of New York Academy of Sciences. Pp. 27.

Eradication of Syphilis and Crime. By George F. French, M. D. Portland, Maine: Berry print. Pp. 8.

Conservation of Force. By Thos. H. Musick. Mexico, Missouri: *Union* print. 1878. Pp. 56.

The Amateur's Handbook of Practical Information for the Workshop and Laboratory. New York: The Industrial Publication Co. 1878. Pp. 44. 10 cents.

Natural Succession of the Dicotyledons. By Lester F. Ward. From the *American Naturalist.* Pp. 11.

POPULAR MISCELLANY.

What Medicine owes to Galileo.—In a lecture on the history of instruments of precision in medicine, a synopsis of which is published in the *Medical Record*, Dr. S. Weir Mitchell gives to Galileo Galilei the credit of having contrived the first instrument of this kind, viz., the pulsilogon. Desiring to apply some test of the regularity of the swing of the lamp-pendulum in the Pisa cathedral, he is said to have used that most wonderful of clocks, the pulse, for that purpose. This was a grave moment in the history of medicine—"the birth of precision," says Dr. Mitchell. From this use of the pulse as a test of the regularity of the pendulum he was led to use the pendulum as a measure of pulse-rate—thus making the pendulum a *pulsilogon.* The method of using it was most ingenious. Having always a pendulum of equal weight, he set it swinging, and then shortened or lengthened the string until the beats corresponded with those of the patient's pulse. Then he measured the length of the string, and one person's pulse would be represented arbitrarily but most precisely by say ten inches, another's by eight inches, and so on. Galileo seems to have given little thought to the perfection of this instrument, and does not speak in any of his essays of the medical use of the pendulum. Many years later Sanctorius described an instrument for measuring the pulse which was in no respect different from that of Galileo, and which was called by the same name—pulsilogon.

Plant-Respiration.—From experiments made by Mr. J. Jamieson, and published in *Nature*, it would appear that fresh sections of many fruits and other vegetable structures, as potato, give the characteristic reactions of ozone, viz., causing separation of iodine from iodide of potassium, and turning tincture of guaiacum blue, the intensity of the reactions depending mainly on the comparative freshness of the fruits and vegetables. Mr. Jamieson further finds that these structures contain a substance which acts as an ozone-carrier, or *Ozonträger*, to use Schönbein's expression, a substance which transfers ozone from hydrogen-peroxide, and similar bodies. This is shown by the fact that, if the guaiacum is not blued at all, or only slightly, the blue color becomes very marked when a drop of ethereal solution of hydrogen-peroxide is added. From these observations the author infers—1. That the oxygen inhaled by living plants, and even by pulled fruits, for a time is ozonized, probably by entering into loose combination, as is the case with oxygen in the blood of animals; and, 2. That it is probable that the ozone-transferring substance existing in almost every fresh vegetable structure is that with which it is loosely combined, as the oxygen in the blood is with the hæmoglobin of the red corpuscles. This element in plants is gradually destroyed as decay comes on, and ceases to perform its ozone-transferring function when the fruit, etc., containing it is cooked. It is not chlorophyl, as is shown by its situation, and it seems to be intimately associated with the vascular tissue. From analogy with the animal substances, hæmoglobin, fibrin, myosin, etc., which have a similar action, it may be presumed to be proteinaceous, though the author is unable more exactly to indicate its chemical and other characters.

Growth of Mining Engineering in the United States.—Thirty years ago the profession of the mining engineer was almost unknown in the United States; to-day the American Institute of Mining Engineers numbers over 700 members. The state of things which existed thirty years ago will be understood from the following passage, which we take from Mr. E. B. Coxe's presidential address to the members of the Institute at its last meeting: "Of the few we then had worthy of the name of 'mining engineer,' some studied in the Continental academies, and others were graduates in the school of practical experience, and had learned their profession in mines and smelting-works. Their work consisted principally in making surveys and maps of mines and mining properties, geological reports, and analyses of ores; but the mining engineer, whom we often meet with now, who has studied chemistry, physics, mineralogy, geology, mechanics, and drawing; who is more or less familiar with machinery and its construction, and with the practical

management of mines or smelting-works, and who is an *expert* in some one branch of his profession—would have been very difficult if not impossible to find in the United States. The inducements held out to ambitious and talented young men to enter the profession were, it must be admitted, very small. By a large portion of the community, a mining engineer was considered to be merely a bait with which unsophisticated capitalists were to be caught, and his opinions were considered to be worth so much a page, and to favor any view which his employer wished to have advocated. He was seldom consulted as to the proper method of working a mine or running a furnace; he was rarely called upon by directors of works, except for extraordinary work, such as to give the direction in which a tunnel should be driven, or to analyze a new ore or limestone. There was no recognized standard in the profession, and there were great openings for unprincipled adventurers, of which many charlatans took advantage. Up to within fifteen years, mining engineers were too often regarded by those who had dealings with them with great distrust, and well-educated persons may yet be found who have no idea what a mining engineer is, nor what he is called upon to undertake. This feeling is, however, wearing away. We now have mining engineers whose names are as well known abroad as at home; whose opinions are respected and paid for, although, I am proud to say, they cannot be bought. We have schools whose graduates are well qualified to enter the ranks of the profession when they have obtained the proper practical experience; and there are few parts of the country without mining engineers of established reputation, unless, in consequence of the peculiar condition of the locality, there is no need of their services."

Studies of a Mummy.—Mr. Frank Buckland, having received from a friend who had been visiting Egypt a mummy-head, set about examining the curiosity, with what results he informs us through the columns of *Land and Water*. From the general contour of the head he infers that it is that of a woman. The actual features cannot be seen, being covered with a sort of mask of linen cloth. Underneath this can be discerned the outlines of the face; the pupils of the eyes are marked with a black spot. The mummy wears a wig! Mr. Buckland found the whole head covered with what at first appeared to be rolls of hair, but which turned out to be an imitation of hair. The rows forming this wig are arrayed in three tiers, overlapping each other. The lowest tier begins from the top of the ear, and runs almost straight across the forehead; it is not unlike the fashion of hair worn by some ladies of the present day. "To try the effect," adds Mr. Buckland, "I put a modern, smartly-trimmed hat on the head of this Egyptian lady. I see that the fringe of hair is the same as the fringe of the present time. On the whole, there is a little more *chic* about it." Having washed one side of the mummy's face with warm water and a sponge, and again put on a modern hat, he was more convinced than ever that the head is that of a lady—"very good-natured and smiling."

Effects of English Rule in India.—Mr. C. Macnamara, surgeon to the Westminster Hospital, London, was for twenty years engaged in practice in India, and during that time had every opportunity of learning the feelings and opinions of the natives regarding the present state of things in that country. According to Mr. Macnamara, the deep and growing conviction of many of them is that, although England has in India preserved many millions of human beings from the calamities of anarchy and chronic warfare, nevertheless native society is becoming rapidly disorganized. A vast number of the old families have disappeared; the mothers and wives of the rising generation see their educated sons and husbands given over to vices formerly never heard of, utterly heedless of family or any other ties, and they contrast all this with times past, when there was not so much law, education, or taxation, but when the greatest stain that could be cast on a man's name was that of being an undutiful son. In Mr. Macnamara's opinion all this results from "purely secular education." The rising generation of educated Hindoos break away from the native religion, entirely ignore the existence of a God, and live absolutely for self. "The outcome of a

purely secular education," writes Mr. Macnamara, "is gross materialism and rank socialism. Hence the necessity of suppressing the vernacular press, a measure calculated, it may be, to smother for a period one of the many outlets by means of which Europeans had an opportunity of ascertaining the state of feeling among the natives of the country, and which [*sic*] I fear will too certainly burst forth in an insurrection in comparison with which the mutiny was a mere brawl."

Our Parks.—In a recent paper on "Our Parks," read before the New York Academy of Sciences, Dr. E. Seguin vigorously protests against the policy that is rapidly surrendering the Battery to commercial uses, and destroying its value for æsthetic and health-giving purposes. The beautiful view of the harbor which the Battery once afforded is gradually being narrowed: to the west by Castle Garden, formerly a simple terrace—a lookout, now an immigrant-shed; toward the east six buildings form an immense barrier, behind which none would suspect how near the ocean displayed its ever-changing scenes; from the sea the city looks as if inclosed by barracks, from the land it is the sea that appears to be imprisoned. The little space for an outlook remaining is now threatened with invasion by Government buildings, the city consenting with offers of additional land if required. A total obstruction of the view will follow next, completing the severance of the city from the bay, and presenting the shocking contrast of a harbor unequaled in grandeur leading up to a row of barracks on the water-front—no monuments in view, the ocean-breeze shut out, all perspective destroyed; the whole scene a violence to the eye and an humiliation to patriotic pride.

Preceded by the destruction of St. John's Park, and the attempt of last year to ruin the Washington play-ground, Dr. Seguin regards this as a third plot against the best interests of the city, coolly set to execution for no *apparent* purpose save the destruction of what is both a health resort and a powerful educating agency for the children and youth of the metropolis; and thus blunting the sense of the beautiful by cutting them off from the enjoyment of the natural scenery of which New York, above all other cities, is the fortunate possessor.

All right-thinking people will agree with Dr. Seguin that an exactly opposite policy should be adopted and carried out by the municipal authorities. This whole shore up to its original limits should be thrown open to the bay, and made to present to the stranger the noble face of a great city, the hospitable welcome of a great nation. It should be made an entrance of honor for distinguished guests, where the greetings of a cultured people could not be drowned by the rush and turmoil of trade. It should be rescued from its present and prospective degradation, and, by a wise combination of Nature with art, converted into a school for the millions that in future generations would make it a resort. To this end says Dr. Seguin: "The waves of the bay should be made to expire in marble basins, fronting the widened entrance to Broadway, perceptible through the trees. Where the land and water meet the vegetation, transformed from terrestrial to aquatic, may extend from the shore to the reefs beyond, and here also could be established subterranean aquaria, whose population might be made more varied and rich in the life of the sea than that which now delights and instructs the visitors at Brighton." Dr. Seguin gave several interesting illustrations of the great influence exerted by early impressions in shaping the future of the individual, and contended that every opportunity should be seized to make such impressions contribute to elevation of character, and to the encouragement of noble aims. He also called attention to the advantages that would follow the union of outdoor with indoor teaching by what he terms the mobilization of the schools.

The Light of the Sun's Corona.—Before the occurrence of the solar eclipse of 1878, Mr. W. T. Sampson, U. S. N., made elaborate preparations for studying minutely the corona's spectrum, with the sole view of deciding, by the absence or the presence in it of dark lines, whether the light is reflected sunlight, whether it is due to the self-luminous matter of the corona, or whether it is due to both of these causes combined. In the *American Journal of Science* he

describes the instruments used for this research, and the manner in which they were employed. His conclusion is that, inasmuch as he failed to see in the corona spectrum the dark lines of the sun's spectrum, therefore the light of the corona is *not all* reflected light. The considerations which confirm him in this conclusion he states as follows: "Until this eclipse no observer has ever seen the dark lines in the spectrum of the corona except M. Janssen, who reported dark lines, notably D in 1871, but much more difficult to see than the bright lines. Several observers during the recent eclipse failed to see the dark lines, though they looked for them carefully. While I do not question the results of observers who report the presence of dark lines, I think all the observations taken together show that the continuous spectrum of the corona is not the spectrum of the sun. Aside from this, Prof. Arthur W. Wright made measurements of the polarization of the light of the corona, the first time, I think, it has been attempted, and has found the polarization to be but a small percentage of the whole light emitted. Although all reflected light does not reach us as polarized light, yet I think the small percentage of polarization, taken with the faintness of the dark lines, indicates that the corona is, to a considerable extent, self-luminous. The meteoric dust not only reflects the sun's light, but it is continually showering upon the sun, and in its passage through the atmosphere is rendered incandescent."

Investigating the Cotton-Worm.—Prof. A. R. Grote is at present visiting the cotton-growing States for the purpose of studying there the habits of the cotton-worm, and more particularly of determining whether the fly from which it comes is acclimated in those States, or whether it is annually imported. The latter opinion, as our readers are aware, is the one held by Prof. Grote, and it appears to be confirmed by this later investigation. According to his theory, the fly comes from the West Indies with the south winds every year. Having reached our cotton-producing States it there raises its first brood. The eggs are deposited on the under side of the cotton-plant leaf. In about three weeks the young worm "webs up" and becomes a black chrysalis in a thin cotton-cocoon within a fold of the leaf, and in due time the perfect insect emerges. This new fly, born in the South, moves in a general northerly direction, and in this way the country is overrun by the several ensuing broods. If the worm appears while yet the plant is young, the planter can exterminate it by the use of poison; but if it comes late it will not do harm enough to warrant much expense in killing it. Paris-green in a liquid form, or dilute carbolic acid, kills the worm when applied to the under side of the leaf as spray. Care must be taken to keep these poisons from the seed-cotton, and they should only be employed against the first brood of worms before the bolls open.

An Eastern Fish-Story.—A series of interesting letters is now appearing in *Land and Water*, entitled "Recollections of Bangkok," and in one of them a good description is given of the mode of capturing insect prey, followed by a species of "archer fishes," several specimens of which are kept in a small pond in the grounds attached to the palace of the "Second King" of Siam. It is much to be regretted that the author neither describes these fishes nor notes any particulars by which the species might be determined. Our readers will find in the Monthly for January, 1878, an illustrated paper on "Archer-Fishes." When the writer in *Land and Water* came to the pond its finny inhabitants were found to be in a high state of excitement, the cause of which was soon evident. "A small branch covered with black ants had been picked by one of the attendants off one of the overhanging trees; and, holding this a few feet over the pond, volleys of minute globules of water were directed at it from the mouths of all the little fishes crowded underneath. This was continued until all the ants were knocked off into the water. Then ensued a scramble for the prey. Any small insect within their range met the same fate, and they shot with the most unerring aim. As I stood watching the curious sight, close to the edge of the pond, a small fly lighted on my hand, but was hardly seated before a volley of watery bullets knocked him off his perch, though at a range of four or five feet.

These little fishes are, I believe, only known in some parts of Siam and Burmah; they are small, not more than six or seven inches, and in shape like a smelt. I am not aware that I have ever seen any description of them."

"Are the Elements elementary?"—Mr. Norman Lockyer has realized the alchemist's dream, the transmutation of metals. In the presence of a small party of scientific men, Mr. Lockyer, by the aid of a powerful voltaic current, volatilized copper within a glass tube, dissolved the deposit formed within the tube in hydrochloric acid, and then showed, by means of the spectroscope, that the solution contained no longer copper, but another metal, calcium, the base of ordinary lime. The experiment was repeated with other metals and with corresponding results. Nickel was thus changed into cobalt, and calcium into strontium. All these bodies, as is well known, have ever been regarded as elementary—that is, as incapable of being resolved into any components, or of being changed one into another. It is on this basis that all modern chemistry is founded, and, should Mr. Lockyer's discovery bear the test of further trial, our entire system of chemistry will require revision. The future possibilities of the discovery it is difficult to limit. The great object of the old alchemists was, of course, to transmute base metals into gold, and so far as our knowledge goes there is no reason why copper should not be changed into gold as well as into calcium. The means at present employed are obviously such as to render the process far more costly than any possible results can be worth; but this is necessarily the case with most scientific discoveries before they are turned into commercial facts. Mr. Lockyer is one of our best living spectroscopists, and no man with a reputation such as his would risk the publication of so startling a fact as he has just announced to the scientific world without the very surest grounds. He is known by his friends as somewhat sanguine, and he does not pretend to be an accomplished chemist, but he was supported yesterday by some of our leading chemists, all of whom admitted that the results of his experiments were inexplicable on any other grounds but those admitting of the change of one element into another, unless indeed our whole system of spectrum analysis is to be upset, the other horn of a very awkward dilemma. Since a hundred years ago Priestley discovered oxygen and founded modern chemistry there has been—there could be—no discovery made which would have such an effect on modern science as that the so-called elements were no longer to be considered elementary.—*London Daily News.*

NOTES.

A gold medal has been awarded to Mr. Edward R. Andrews, of Boston, for his exhibit of creosoted wood at the Exhibition of the Mechanics' Charitable Association in Boston. The article on the *Teredo navalis*, by Prof. von Baumhauer, in the August and September numbers of this journal, was translated by Mr. Andrews. This paper explains the merits of creosote-oil in protecting timber from destruction by marine worms and insects.

Concerning the manner of Mr. Thomas Belt's death, the *American Journal of Science* has the following information: "About two weeks previous to his death Mr. Belt had shown signs of insanity, and it was thought best to remove him to New York. Mr. Silas Lloyd, who had for a short time been associated with him, accompanied him. Just before arriving at Kansas City, Mr. Lloyd had occasion to leave him for a few minutes. On returning, he found the door locked. Mr. Belt refused to let him in, and commenced a furious onslaught on furniture and car. Parties crawled through the broken windows, and succeeded in pacifying him. Getting him off the train, he was prevailed upon to drink a glass of milk, and about twenty minutes afterward he died."

A note was read in a recent meeting of the Paris Academy of Sciences, from Mr. J. Norman Lockyer, in which the author says that he believes he has succeeded in proving that many of the "elements" are in reality compound bodies.

The *Iron Age* reports the discovery in Franklin County, Pennsylvania, of very rich deposits of copper, occurring in the form of hydrous carbonate or malachite, containing about seventy-two per cent. of copper oxide or fifty-seven and a half per cent. of metallic copper. Some of the deposits show even a higher percentage than this.

A monkey in the Alexandra Palace, London, had a decaying tooth, and suffered from a large abscess in the lower jaw. It

was decided to extract the tooth, but, as the animal was at times very vicious, it was thought that chloroform would have to be employed. He showed fight on being taken out of his cage, and struggled hard against being put into a sack, snapping and screaming at the attendants. But so soon as the dentist managed to get his hand on the abscess, and so gave a little relief, the monkey's demeanor changed entirely: he laid his head down quietly for examination, and quietly submitted to the removal of a stump and a tooth.

In a series of experiments undertaken with a view to discover an effective method of preserving animal substances, Dr. B. W. Richardson discovered that flesh which is alive in the body of an animal possesses a neutral reaction, being neither acid nor alkaline; but that after an animal is killed, and the flesh is exposed to the air, there is quickly set up an acid reaction which lasts as long as the dead structure remains "fresh." As the structure begins to change, the acid reaction becomes neutral, and from that it soon passes to become alkaline. This alkaline reaction may be considered as an evidence of putrefaction.

A select committee of the National Academy of Sciences, appointed to consider what changes are needed in the conduct of the surveys of our Western States and Territories, has made a report in which they recommend a radical change. They favor the abolition of the present surveys under Hayden, Powell, and Wheeler, respectively, and the transfer of the work to the Interior Department. It is proposed to make the Coast Survey the nucleus of a grand system of scientific exploration and survey.

The efforts of the Fish Commissioners of Maryland to stock the waters of that State with California salmon are proving eminently successful. At Havre de Grace and other points on the Susquehanna, salmon are beginning to make their appearance, and many of good size have been taken. During the season of 1878 three hundred thousand salmon have been distributed in Maryland waters.

A ludicrous miscarriage of justice has occurred in England. Judgment having been entered against a shopkeeper for selling watered milk to a food-inspector, appeal was made to the Lord Chief Justice, who reversed the original judgment. An appeal in Scotland has had a like result. The ground of this judgment of the higher courts is the fact that, in order to make the seller of an adulterated article liable, the sale must have been made "to the prejudice of the purchaser." But as the inspector is not "prejudiced," the seller must go free!

It is firmly believed by the people who inhabit the region around Mount Ararat that no man has ever ascended to its summit—indeed, that the feat is impossible. But precisely this *impossible* feat has been performed by an Englishman—Mr. Bryce. But the popular belief persists all the same. When Mr. Bryce told the archimandrite of the district that he had made the ascent, the old man merely smiled, and reaffirmed the impossibility of reaching the summit.

The best quality of lime-juice for antiscorbutic purposes is produced in the island of Montserrat, West Indies, where three hundred acres of orchard-ground are devoted to this culture, the number of lime-trees being about a hundred and twenty thousand.

In advocating the projected astronomico-meteorological observatory of Mount Etna, Mr. G. F. Rodwell takes occasion to mention the extraordinary brilliancy of the midnight sky as observed by him during an ascension of Etna in August, 1877. Myriads of stars which he had never seen before were visible, and the whole sky was studded with stars of every magnitude, color, and brightness. The meteors were "too numerous to count;" the stars themselves shone with extraordinary scintillations. One effect in particular was noticed, for which it is not easy to account, viz., the apparent lowness of the sky, which "appeared to be almost pressing down upon one's head, while the larger stars seemed to be *suspended below the sky*. A good telescope," he adds, "brought to bear on such a sky would reap a harvest of results."

In the root of the strawberry-plant (*Fragaria vesca*) Dr. T. L. Phipson has discovered certain substances closely allied to those obtained from cinchona-bark. There exists in this root a sort of tannin of a very pale-yellow color, soluble in water and in alcohol, and which strikes a green color with iron salts. It is soluble in water slightly acidulated with hydrochloric acid; but with more hydrochloric acid it combines to an insoluble compound. This substance, called by Phipson *Fragarianine*, is really a sort of tannin, closely allied to quinotannic acid, but instead of yielding *cinchona red* like the latter, it yields a somewhat similar substance, which Phipson calls *Fragarine*. The process by which this substance is obtained is fully described by Phipson in a paper read before the British Association.

Iridescent glass is made by burning chloride of tin in the furnace. Fumes are thus produced for which warm glass has great affinity, and which immediately produce an iridescent surface upon it. To heighten the effect, a small quantity of the nitrates of baryta and strontia may be used.

ELISHA GRAY.

THE

POPULAR SCIENCE MONTHLY.

FEBRUARY, 1879.

DARWIN *VS.* GALIANI.[1]

By Professor EMIL DU BOIS-REYMOND,
OF THE UNIVERSITY OF BERLIN.

IT was a hundred years ago, in the *salon* of the Grand-Val, after dinner. Here was assembled that fastidious company of wits as well known to us through the letters of Diderot to Mademoiselle Voland as though we, too, had been guests under Holbach's roof. There was Diderot himself, the most German-like of Frenchmen, and Grimm, the most Frenchy of Germans[2]; that peevish Scot, Hoop, and the little Neapolitan abbé, Galiani,[3] in whom playfulness and levity often concealed profound thinking. There, too, were those women whose redoubtable charms are immortalized in Rousseau's "Confessions," as those of Helen in the "Iliad" and "Odyssey."

The fortunate ones of this world had then a good time, especially in France. The trammels of superstition which for seventeen centuries had made slaves of the human race seemed to have been burst asunder. The sun of a cloudless day was illumining and warming the intellectual world; while on the other side of the Atlantic the dawn of popular freedom and human dignity was beginning to appear. Despotism in church and state was tottering before assaults which daily

[1] Translated from the German, by J. Fitzgerald, A. M.

[2] Sainte-Beuve, "Causeries du Lundi," third edition, vol. ii., 1858, p. 203.

[3] Ferdinand Galiani was a native of the province of Abruzzo, Naples, born in 1728. He was no less remarkable for wit than for solid acquirements. Having made a collection of specimens of the volcanic products of Vesuvius he sent them to the Pope in a box thus labeled, "Beatissime pater, fac ut lapides isti panes fiant" (i. e., Most Holy Father, command that these stones be made bread); in answer to which the Pope gave him the canonry of Amalfi, with four hundred ducats per annum. He wrote a treatise on "Money," "Annotations upon Horace," "Dialogues on the Corn Trade," etc. He held several important offices under the Neapolitan Government, and died, greatly esteemed, in 1787.—(Cates's "Biographical Dictionary.")

grew bolder; and Cazotte's prophecy[1] had not as yet cast its ominous shadow over this gay and brilliant *coterie*. Moreover, what was there now that man might not do, after Montgolfier had ascended in the air, and Franklin had subdued the lightning?

The company talked first of the great American citizen; then of the great Frederick, who also was conceded to be somebody; next of Voltaire, with whom Frederick seemed to be fully reconciled. But, with all their worship of Voltaire, and with all their willingness to recognize his services in the cause of enlightenment, there was no getting over the fact that, in truth, he was an incorrigible deist.[2]

"How childish," remarked the host, "is his conception of the universe as a watch from which we may infer the watch-maker! Inasmuch as nothing is certain save the existence of matter, why look for any other causes than the forces of matter? What is there so inconceivable in the idea that an infinity of atoms, acting upon one another from eternity, should assume a definite arrangement, and so form worlds; that when in these worlds light, heat, moisture, and certain elements were present in the right proportions, the phenomenon which we call life should first appear as a germ, and then expand into ever-widening and more varied circles; that in this way the animal mechanism, and, finally, that of man himself, should have come into being?—a well-contrived mechanism, indeed, but not without many an imperfection; endowed with strength and beauty, but also afflicted with many a sad infirmity; capable of enjoying many a pleasure, but also threatened, alas! with still crueler sufferings."

There was general assent, but then were heard coming from a corner the piping tones of Galiani's voice:

"Ladies and gentlemen, for Heaven's sake, no metaphysics to-day! Let us talk of something else. Suppose I tell you of an occurrence I once witnessed on the Marina at Naples. A juggler had set up his booth, around which stood a group of lazzaroni and other folk, myself among them. After performing sundry tricks which have escaped my memory, the fellow offered us a wager that he could every time, with his dice, throw sixes. One or two of the gapers took up the bet. He did, in fact, throw sixes the first time, the second, third, fourth—"

"But, monsignor, this is a farce; either you are joking, or else the dice were cogged."

"Of course they were," Galiani replied. He had, as was his wont, climbed into his arm-chair, on which he squatted with his legs doubled up beneath him; he had his wig poised on his left hand, for the weather was hot, and, with his right, he gesticulated wildly, after the manner of his countrymen. "Of course they were cogged, and that was just the trick. The juggler did not say that he would throw sixes every time

[1] "Œuvres choisies et posthumes de M. de la Harpe," Paris, 1806, tome i., p. 62.

[2] E. du Bois-Reymond, "Voltaire in seiner Beziehung zur Naturwissenschaft," Berlin, 1868, p. 19.

with honest dice. Any man in his senses might have known beforehand that the dice were cogged, and the fellows who found this out only after their money was gone were laughed at heartily. But the point of the story is this: If two dice fall on the same side four times in succession, you, not being lazzaroni, hold it to be impossible that the thing should happen by accident. You conclude, with undoubting certitude, that a hidden cause, designed to produce this effect, has been incorporated in the dice, in the shape of a little lead. But, when you see all around you this universe, with its innumerable suns, planets, and moons, which, poised in vacancy, have for thousands of years been rhythmically traveling in their courses, without ever a collision; when you see on this globe dry land, sea and atmosphere, sunshine and rain, so distributed that myriads of plants and of terrestrial, aquatic, and aërial animals swarm in joyous life; when, for all these creatures, you see the alternation of day and night, of winter and summer, beneficently answering, in all respects, to the requirements of activity and rest, cessation and growth; when, in your own body, you see each particle of its ineffably complicated structure performing exactly the functions which the good of the whole organism demands, while in turn it can itself subsist only in the whole; when, in your own members, your eye, your ear, you see the profoundest science of the mechanician or the optician so far transcended that our friend D'Alembert and the great Euler yonder in St. Petersburg, *e tutti quanti*, appear as fools; when you see this machine—alongside of which your Le Roy's finest watch is, as it were, some coarse piece of mill-gearing, your Vaucanson's most ingenious automaton a wretched toy—perfecting itself by practice, making its own repairs; when you see it even reproduce its own kind, and male and female most charmingly, mother and child most beautifully adapted to each other; when, in the Jardin du Roi, under a thousand animal forms, from the elephant to the shrew-mouse, M. de Buffon shows you as many types of your own organization, each one adapted in its own way for the enjoyment of life and the pursuit of its prey, for defense against its foes, for propagation of its kind, and for care of its young; when you see the bees solving their cell-problem as correctly as the most learned of mathematicians, the spiders bracing their polygons of silken threads, the mole excavating its galleries, the beaver constructing its dams; when, further, in all these instances you see the agreeable combined with the useful, and magnificence, ornament, and grace everywhere lavishly displayed—Flora's children clothed with beauty, the gaudy butterfly flitting about among them, the peacock spreading his tail-feathers; finally, when Mr. Needham shows you, under his microscope, how each drop of vinegar or of paste is alive with creatures as numerous as the worlds you have been able to descry through M. de Cassini's telescope—you confidently say that all this is chance. And yet the spectacle presented to us by nature is the same as though some one were every instant, with an infinite number of dice, to make exactly the

throw which he announces in advance. I judge differently, ladies and gentlemen. I say that nature's dice are cogged, and there, above, is the greatest of jugglers making sport of us."

What reply was, on the spot, made to the abbé we know not. But of the impression which the apologue of the cogged dice made on the encyclopædists we learn something from a passage in the "Système de la Nature," that work which, in the opinion of the young Goethe and his Strasburg associates, was "senile, cimmerian, cadaverous, the very quintessence of senility, offensive to all correct taste, nay, insipid." And yet it is not to be denied that the "Système de la Nature," in most points, very nearly represents the idea of the universe now held by scientific men.

In that work Holbach vainly squirms to escape from the snare in which he had been caught by the Neapolitan. "The molecules of matter," says he, "may be likened to cogged dice, i. e., they always produce certain effects of a determinate kind. Inasmuch as these molecules are in themselves and by their combinations essentially diverse, we may say that they are cogged in infinitely diversified ways. The brain of Homer or of Virgil was nothing but an aggregate of molecules, or if you please of cogged dice—i. e., things so constituted and so elaborated that they must of necessity produce an Iliad or an Æneid."

To say nothing of the fact that Holbach speaks of mental phenomena being produced by material conditions as of a self-evident proposition, nothing could be more awkward than the mode in which he strives to wrest the weapon from the hand of his opponent. By adopting the comparison of the molecules of matter with cogged dice, he unwittingly admits that in nature, just as in a gambler's den, there is trickery; whereas the problem before him was to explain how material particles not directed toward any definite end should nevertheless coöperate to that end.

Here is the knot, here the enormous difficulty, that racks every understanding that would comprehend the universe. Whoever will not surrender all occurrences into the hand of Epicurus's Chance, whoever admits even the veriest tittle of the doctrine of teleology, must perforce accept Paley's disparaged *natural theology*, and this the more inevitably the more clearly and accurately he reasons, the more independently he exercises his judgment. But so weighty and so numerous are the facts which seem to favor teleology; so irresistibly do these facts daily force themselves upon us in common life; so interwoven are final causes with time-honored imaginations of our race instilled into us during childhood, that even minds possessed of considerable powers of abstraction can not in their habitual thoughts refrain from postulating them. A man may, with Lichtenberg, ridicule the teleological explanations offered in earlier times. Be he ever so determined to regard the processes occurring in the animal body simply as effects produced by the mechanical or chemical organs, and so to represent them to others,

nevertheless presently he finds himself speaking of the use, functions, and purposes of the organs.

The possibility, however remote, of banishing out of nature this apparent adaptation to ends (teleology), and of everywhere setting up blind necessity in the place of final causes, is to be regarded as one of the greatest advances ever made in the world of thought, as a step from which will be dated a new epoch in the treatment of these problems. That he has in some measure diminished that torture of the mind which tries to understand the universe, will be Charles Darwin's highest title to fame so long as there exists a philosophic student of nature.

Mr. Darwin's "Origin of Species" undoubtedly found zoölogy, botany, and paleontology in a state bordering on *doctrinaire* lethargy. The knowledge of organic forms was daily increasing in an overwhelming proportion. The sole concernment of scientific men was, as far as possible, to classify the superabundant harvest in the existing systematic frame-work; and where this could not be done, to extend the latter and add to it on this side and on that, as need was. Natural history in its narrower sense, i. e., the study of the modes of life and the instincts of animals, was hardly to be found anywhere save in books for children. As for ascertaining the meaning of the facts gathered up by naturalists, as for any theory of organic beings, such things were hardly so much as thought of. The ancient dogmas of the immutability of species—a conception which, however, no one was able to define—of the infertility of hybrids, of successive acts of creation, of the impossibility of spontaneous generation, of the recent origin of the human race—these dogmas precluded all effort in that direction. The earlier attempts, in our own time brought to light again, of Lamarck and others, at solving this problem with the aid of insufficient data, and in part from the point of view of nature-philosophy, had fallen into oblivion, and long since it was the custom to regard it as irresolvable by natural science. Independent thinkers who would not bow down before the infallibility of the school were solemnly admonished of the error of their ways. For there existed a hidden community, composed for the most part of people who were unconnected with the zoölogical school, but to which many also within the school now profess to have belonged, though at the time they showed no symptom of it: this party already entertained secret doubts concerning the inerrancy of the received dogmas. Johannes Müller himself, who in other respects clung to these dogmas with strict orthodoxy, who as a professor inculcated them on his pupils, and who labored with indefatigable industry in building up the orthodox system, betrayed, on the occasion of his discovery of the development of *Mollusca* in holothurians, heretical tendencies which brought him into no little trouble with the school.

It is a pity that he did not live to witness the catastrophe which only one year after his death overtook this very self-assured school.

The disaster was of a kind never before seen in the history of Science—so long preparing and yet so sudden; so quietly planned and yet so mighty in its effect; a scientific event without a parallel, whether we consider the extent and the importance of the system which was overturned, or the reverberations of the downfall to the uttermost limits of human knowledge. Just as, after the overturning of thrones, the neighboring countries are for a long time all commotion and tumult, whereas in the center of the disturbance itself new institutions are beginning to take root, so in consequence of the Darwinian movement the always unsettled border-land between science and philosophy is yet in a state of violent fermentation, as we see nearly every day from the many-hued bubbles of literary effort which come to the surface. But in the field of calm and earnest science this first turmoil has given way to more quiet contemplation. Already a new generation, which has grown up amid this revolution, is beginning to take the lead with renewed courage. Leaving out of the account a few cross-grained geniuses, whose lamentations we can disregard and pass to the order of the day, it is on all sides admitted that the old ground was untenable, and that in the place of Cuvier's and Agassiz's series of creations must be substituted Mr. Darwin's doctrine of descent.

At the same time the opinion seems to be steadily growing that the evolution of organic nature is to be explained only by the so-called laws of organic structure. The peculiar merit assigned to Darwin is that he has gained the victory for the doctrine of descent. On the other hand, the doctrine of natural selection is regarded, at the best, as an ingenious idea, set forth with much skill, but in point of fact of no value.

This view, in my opinion, calls in question the very best portion of the new advance in science.

Compared, indeed, with the doctrine of the systematic school, as it reigned unquestioned in manuals and lecture-rooms down to the publication of Darwin's work, the doctrine of descent appears in itself to be a great step of progress. None can be more ready to admit this than they who therein see the triumph of their own views, silently entertained; none can more highly esteem than these pre-Darwinian Darwinists the merit of having aided in giving to the doctrine of descent its present commanding position. Still it was not to be expected that these men should feel as much indebted, intellectually, to the doctrine of descent, as others who before were not quite certain whether whales didn't come forth ready made out of nothing; whether each species manufactured at pleasure by the ornithologist or the entomologist was not created in the beginning, and did not enter Noah's ark. If naturalists of this class, though now they accept the doctrine of descent, are nevertheless a little uneasy in their consciences, and wonder at their own audacity, it is, on the other hand, perfectly natural that those older adherents of the doctrine of descent should not rest content with the triumph of their

views, but that they should follow even in his further conquests the great leader who by a single blow won the victory for their side. But the end which he points out to us is high above the doctrine of descent, which doctrine, in so far as it attempts to explain the evolution of organic nature solely by its laws of development, is in fact still of little avail to us.

We must remark, in the first place, that what morphologists denominate laws are not laws at all in the sense of theoretical science. These so-called laws are simply rules deduced from a greater or less number of cases, and like grammatical rules only serve to classify and explain, by a process of vicious circle-reasoning, other facts embraced within the same definition. Even Kepler's laws were but rules of this kind, until Newton deduced them from the universal law of gravitation, and so raised them to the dignity of laws. But now that they are firmly based on the principle of gravitation, the whole doctrine of the movements of the heavenly bodies may be inferred from Kepler's laws with the highest attainable degree of certitude; and our longing to know the causes of things is as fully appeased by this explanation as the nature of the human understanding will permit. We know, with that kind of certitude which we denominate absolute, that, like the planets of our own solar system, so those of unseen suns move in ellipses whose *radii vectores* describe equal areas in equal times, and that the squares of their revolution times are as the cubes of their distances from their suns.

It is very different with the laws of organic structure. If in a Jurassic rock we find a fragment of a rhombic enameled scale, we infer with a very high degree of probability that the fish of whose panoply this scale was a part thousands of years ago had an independently pulsating aorta-peduncle. If on breaking up a shapeless piece of fossil bone we discover a spiral auditory cochlea, we know that the animal of whose skull the fragment was a part was a mammal. It is no small triumph that we dare make such assertions as these. Still, there is not absolute certitude here. Even the most firmly established laws of organic structure possess only a greater or less probability. Absolute characters are in systematics the philosopher's stone. True, in some cases the probability grounded on laws of organic development borders on certitude. That we shall never find a centaur, pegasus, griffin, a configuration like that of an angel or a demon, whether living or fossil, we may affirm with almost the same certainty as that a planet which has never been observed will obey the laws of Kepler. Whether we can with equal certitude affirm that never will a vertebrate be found in which by a transposition of the central nervous system the posterior and the anterior roots of the spinal-cord nerves will have interchanged functions, may perhaps be open to doubt, however improbable such a thing may be. Would the comparative anatomist ever have supposed *a priori* that such a structure could exist as that of the *Pleuronectæ?* Then, in the Invertebrata the uncertainty of the laws of organic structure is

in so much greater as the Invertebrata, with perhaps the exception of the Articulata and the Radiata, are less pronouncedly typical and physiologically less intelligible.

This uncertainty of the laws of organic structure comes from the fact that these laws themselves are purely experimental, containing in themselves no ultimate, logically cogent truth such as we find in physico-mathematical laws. Hence, a departure of nature from these rules implies no contradiction, no impossibility; and if a thing is not impossible, of course it is possible.

Physico-mathematical laws form, as it were, a resting-place on which we may safely step without fearing that it will ever fail under our weight. In the history of development, on the other hand, what has been our experience? Within a short period of time, a very restricted survey of the animal world, a survey guided by chance, made us acquainted with a series of facts that conflict with all our previous knowledge. Discoveries like that of the inverted position of the embryo in certain rodents, of the development in the deer, of alternate generations, of the development of the echinoderms, of the *Entoconcha mirabilis*, of parthenogenesis, of hectocotyly—all these are calculated to put us on our guard against premature generalization in this field. But in fact such anomalies as these are only counterparts of others with which we have long been familiar, as the marsupials, viviparous fishes, etc., which make no impression on us, because already known to science.

Under such circumstances the application of the biogenetic fundamental law to individual cases is very hazardous, even though we admit the principle in a general sense. The inferences which ontogeny, guided by a few scattered paleontological characters, permits us to draw with regard to phylogeny, will never possess more than a very restricted degree of probability. It will ever be open to the individual understanding to take whatever way it chooses amid the confusion of innumerable and complex possibilities, and, excepting a few indisputable points, which, however, were understood long ago, to conceive a great many different modes of development of the organic world as it exists now. As for certain genealogies of our race drawn up in unfettered presumptuousness rather by an artistic imagination than by a scientifically trained mind, they are of about the same value as the pedigrees of Homeric heroes in the eyes of the historical critic. For my part, if I want to read a work of fiction, I can find something better than a "History of Creation."

But this is not the point which concerns us just now. Granting the scheme of descent from the little mass of protoplasm with which life is supposed to have begun, up to man himself, to be clearly made out (which it is not), the fashioning of organic nature will, after all, be as great a riddle as ever, if laws of structure have alone determined its development.

And this, not because molecular mechanics, which produces modifi-

cations of structure, is a sealed book to us, and will for ever remain so. The molecular mechanics of crystallization, of chemical processes, seems, it is true, to be more easily understood than that of cells; still, for the present it is as hidden from us as is the latter, though its unintelligibility is of a different kind. It is the adaptation seen in the development and in the functions of the cell which, even were we acquainted with the descent of all forms, would still leave organic nature a mystery. By laws of structure alone we can not explain adaptation in organic beings. Hence, however complete our doctrine of descent, the ancient riddle which has confronted mankind from the beginning persists with all its original obscurity, unless something else comes to succor us. The sphinx of teleology still threatens unconquered from her crag. What boots it to know the reason why all vertebrates are made up of the self-same homologous parts, if we do not further know what natural cause so transformed these parts as to make them exactly answer to the purposes of each separate species? If, to explain this latter fact, a supernaturalistic intervention is still necessary, then we are yet in about the same old rut. Formerly the question used to be why, in repeated creative acts, Omnipotence always clung to the same models, and at times did only indifferent work? But now we must ask why it should, in advance, have tied its own hands, committing itself to faulty constructions and making it impossible for itself, e. g., to create a vertebrate with six extremities, though in a given case such a plan might be a very serviceable one. Hence we are, on the whole, no better off, and have only altered the form of the problem, without coming nearer to a solution.

In these straits we find in the doctrine of natural selection a measurably acceptable solution. Associated with the laws of structure, it would forthwith enable us to understand why organized beings are so wonderfully adapted to one another and to the world around them; why in themselves they are adapted to these ends, at the same time, however, exhibiting many an inadaptation; why they always stand in groups made up of the self-same parts, as though Nature had not been able to invent something new, while nevertheless each one of these parts is cleverly so transformed as to answer a special purpose in each species. Sexual selection, then, comes in to perfect the weapons, offensive and defensive, of the wooing male animal, and furnishes the answer to the question how animated nature happens to lavish plumage adornment on birds; whereas Maupertuis's theorem of the smallest action precludes any superfluity in inanimate nature. Even the glowing hue of Alpine flowers is accounted for by the attraction which brighter-colored individuals exercise upon the insects scarce in those heights, and necessary for fertilization. And mimicry, a fact brought to light by Mr. Alfred Russel Wallace, to whom we owe an important share in the discovery of the grand principle of natural selection, still further multiplies the conditions under which new forms come into existence and

become fixed. Finally, this principle extends into the field of psychology and throws light even upon the origin of our ethical aspirations. In short, in lieu of final causes we would have in organic nature a most complex but blindly acting mechanism; and the cosmic problem would be reduced to the two enigmas: "What are matter and force?" and, "How can these think?"

The objections to this doctrine of natural selection are essentially three in number:

The first group of its opponents simply question the facts on which the theory is based, namely, the tendency to variation, the transmissibility of varieties, the fecundity of hybrids, the mutability of species; above all, Darwin's very ingenious explanation of the dying out of intermediate forms. These opponents, however, urge but little beyond the arguments on which the doctrine of the old systematic school rested, and which have been shown by Darwin to be untenable. Still, there is one objection which possesses undoubted weight. I myself early called attention to it in my lectures, in which I believe I was the first public expositor of the new doctrine in Germany. The objection was not printed till much later, so far as I know, and then by Prof. A. W. Volkmann. It is this, that the minute variations in which new species are supposed to have their rise can not be of any material advantage to the individual in which they appear. Still, in my opinion, this objection applies only in certain cases, and perhaps only provisionally. In the case of electrical organs, for instance, it still seems to be unanswerable, for we can not assign any possible use for the so-called pseudo-electrical organs. But, as concerns wings, we see in the example of the flying opossum, the flying lemur, and of the flying frog, discovered by Wallace, how difficult it is to say of a rudimentary organ whether it is or is not of advantage to an animal. In short, the question is not whether this or that definite structure, but whether any adapted structure whatever, can be explained in the way pointed out by Mr. Darwin. In many cases of adaptation by mimicry, and of sexual selection, this is admitted by the great majority of naturalists; and this, as we shall see, is for the present enough.

The second group of opponents do not question the general correctness of the principle or the validity of natural selection in certain cases. But they object that the principle does not explain all structures. To suppose that it must, implies a misapprehension. It never was pretended that natural selection could, by itself alone, account for the fashioning of organic nature; laws of organic structure have always been supposed to act simultaneously with it. Mr. Darwin himself has dwelt on this aspect of the problem, but, as was natural, it has no paramount place in his treatise, despite its importance. If I mistake not, in the innumerable essays which have been written on the Darwinian theory, sufficient stress has not been laid on the fact that the laws of organic structure must account for whatever in organisms is either not

adapted or is even dysteleological; while, on the other hand, natural and sexual selection has to account for most of what is adapted or what is present for ornament's sake only, and which is therefore unexplainable by the simple laws of structure. So truly is this the correct view of the case, that in fact the structure of organisms seems everywhere to be a compromise between the requirements of the laws of structure and the effects of natural selection, as we see—to employ an illustration familiar to the physiologist—in the crossing of the air-passage by the digestive passage in lung-breathing vertebrates, an arrangement full of peril to life. On a previous occasion I showed that, in accounting for this state of things, the Darwinian theory coincides, in its results, with the optimism of Leibnitz. Still I am very far from overlooking the difficulties which still remain on this point. One of the most serious of these, in my opinion, is the power of regeneration, as it is called by physiologists, and the nearly allied *vis medicatrix naturæ*, whether as seen in the healing of wounds, in the circumscription and compensation of internal morbid processes, or—at the outermost end of the series—in the reproduction of a complete fresh-water polyp out of each of the two halves into which one such polyp has been divided. This power could not have been acquired through natural selection; and here it seems inevitable for us to recognize laws of structure working toward an end. But have we not a like phenomenon in the restoration of mutilated crystals, a fact observed by Jordan, Lavalle, Pasteur, Sénarmont, Scharff, and others? So, too, the power which organisms possess of perfecting themselves by practice appears to me not to have yet been sufficiently studied with reference to natural selection.

As a third argument against the theory of natural selection—one which is supposed to negative all its claims to consideration—its opponents always urge in the last place that in no single instance has any one ever actually observed adaptive transformation of an organ by inheritance and selection of the fittest forms. What transformations have been thus effected in the past no man can tell, it is objected; and inasmuch as, even in the future, observations and experiments on this subject seem to be impracticable on many accounts, it is claimed that the doctrine of natural selection is not only an unproved hypothesis now, but that it is fated for ever to remain so. Taking their stand upon this ground, and contrasting themselves with the believers in Darwinism, its opponents boast not a little that they are upholding the standard of strict method, which requires us to accept as demonstrated only what is proved by experiment or by mathematical reasoning.

But this again is a mistake. If it is conceded that any one adapted structure can be explained by natural selection, and if therefore this theory is admitted to be legitimately deduced from legitimate premises, then, in order to suppose the operation of natural selection, wherever it is needed to explain phenomena, it is not necessary for us to actually demonstrate such operation in the individual instance. It might be an

exceedingly difficult thing to distinguish, in the performance of a complex machine, the part played by certain forces, as gravity and inertia, everywhere operating according to known laws. Nevertheless, no one would doubt that gravity and inertia do coöperate in the machine, nor should we for a moment hesitate to ascribe to the one or the other of these two forces whatever subordinate effects are only explainable by each respectively. And so in the present case. Natural selection is not, like the supposititious laws of organic structure, an empirical rule which may to-morrow, perhaps, prove nugatory. Neither, indeed, is it, like mathematico-physical laws, an infallible leading principle governing material events. But, as being a proposition deduced by a chain of valid inferences from universally admitted facts, and at the same time a proposition necessary *in se*, natural selection stands midway between a rule and a law, though it comes nearer to the latter. Hence, of the two evolution principles of organic nature, laws of structure and natural selection, the latter is in theory the surer, whatever may be its shortcomings in practice.

Undoubtedly it were much to be desired that we could in the individual instance demonstrate the working of natural selection, and follow the process step by step. But this we can not reasonably expect to do. Between the work of natural selection for one generation and the result after 100,000 generations, there subsists about the same ratio as between differential and integral. How seldom it is that we are able to understand this latter ratio, even though we subject it to calculation! But do we for that reason question the correctness of our integration? The corresponding problem, in the present instance, would be to investigate and ascertain the evolution of a species through an endless line of generations and under diverse external conditions, while at the same time, as has been already stated, unintelligible laws of structure, working either not adaptively or only accidentally so, enter the problem as undetermined constants, or even as undetermined functions. Though this can not be done, it does not follow that we must misapprehend the ratio between the differential and the integral found for us by nature, as though by a calculating-machine.

Thus, then, so far as the validity of the principle in general is concerned, it may be for us a matter of indifference whether or not in the individual instance we can discern and demonstrate the operation of natural selection. As things stand, it must be operative, and the only question is, whether its influence, as regards quantity, is comparable to that of the laws of structure, or whether other more powerful influences obliterate its effects, so that the adaptation prevailing throughout nature would be attributable solely to the action of these laws. In view of this question, the following appears to me to be the proper attitude of the investigator of nature:

That natural selection can perform what we must ascribe to it in

order to explain thereby the adaptation of organic nature, is no more demonstrated than is the contrary proposition. The aim of the theoretical investigator of nature is to understand nature. If this aim is not to be an absurdity, the man of science must presuppose the intelligibility of nature. Final causes in nature are incompatible with nature's intelligibility. Hence, if there is any way of banishing teleology from nature, the man of science is bound to take it. Such a way is found in the theory of natural selection; and hence we must follow in it. Be it that, in holding this theory, we experience the sensations of a man who as his only hope of rescue from drowning clambers on a plank which can only just keep him above the water: when the choice lies between a plank and drowning, the plank has a decided advantage.

Galiani's apologue does not now puzzle us as once it puzzled the encyclopædists. We should have known how to reply to it, for Mr. Darwin has enabled us to see why it is that nature generally, though not always, throws doubles, and that, too, without cogged dice. And, as in our opinion systematics did not attain its true significance and its full value till now, when it no longer deludes itself with its artificial frame-work of classification, so even in physiology we continue to make use of teleology as an aid in discovery, but with the understanding that, the teleology of organs being apparent only, there will also be much that is unteleological, or even antiteleological.

On the other hand, a man is not to be censured who, under the influence of such impressions as we have described, finds it impossible to believe that all nature, the human brain included, was created by the forces of matter out of a chaotic nebulous sphere. What, at the utmost, seems possible when applied to a minute mass of protoplasm, will appear rather hard to believe even to the most uncompromising monist, when he looks at a human blossom, beaming with grace and genius; and yet the difference between such mass of protoplasm and a human being is a difference simply of degree; in fact, the human being was once a mass of protoplasm. In matters of this kind, personal bias, determined by natural constitution, education, and accidental influences, will ever play a great part: Teleology and Vitalism—both in one shape or another as old as mankind—will last as long as the race itself. Hence, let every man take his own course; only, the partisans of Final Causes must not imagine, as they are wont to do, that they offer a better solution of the problem, or any solution at all that is worthy of that name, when they invoke the aid of supernatural conceptions of any sort.

This was well understood by Leibnitz. True, he did indeed suppose that he had discovered a dualistic theory of the universe, but the part he there assigns to final causes proves the correctness of the remark just made. Leibnitz utterly rejected teleology in the material world. Here, for him, reigns mechanical causality, and nothing else. Matter is, according to him, created by God, but at the same time it is so invested once for all with motive force that there is no need of setting

the clock of the universe to make it go right. The sum of matter, like the sum of motive force, remains ever the same. Whatsoever has occurred or ever shall occur in the material world is ideally determinable mathematically. In a word, the material world is a mechanism, only infinitely more ingenious than any mechanism contrived by man, and composed of an infinity of parts inclosed one in the other.

Alongside of this machine of the corporeal world, Leibnitz supposed a spirit world—the world of his monads—whose ideas, from their creation down, keep pace with the changes of the corporeal world and answer to them; but between them and the corporeal world no reciprocal action of cause and effect is possible. On this theory, when we suppose we are working for ends, or that we have sensations produced by external causes, such ideas are preëstablished phantasms of our soul-monad, which is ever presenting to itself exactly the course of things that is passing outside at the same instant, and that seemingly, but not in reality, works through or upon the monad. Once only, miracles apart, has anything been done in the universe for an end, according to Leibnitz, and that was when God created the universe as perfect as he could. How Leibnitz supposed it possible to reconcile his theory with freedom of will, is a question which does not concern us here.

Thus, there was no doubt in Leibnitz's mind that material particles may, in virtue of the forces imparted to them, constitute an apparently teleological universe. Nay, all difference between his and our theory of the material universe vanishes if God created the world infinite ages ago. But even if God created the universe at the finite time $-t$, the course of events necessitated by Leibnitz's theory corresponds perfectly with what it would be in our theory, onward from the instant $-t$. For, inasmuch as Leibnitz looks on the condition of the universe at each instant as a function of time, God could, according to him, create the world in the instant $-t$ only in that condition in which it was at that time, according to our view.

Take away from Leibnitz's theory of the universe the illusory appendage of the monadology, of preëstablished harmony, and of optimism, and the only solid nucleus that remains is his mechanical conception of the material world, and his perception of the impossibility of explaining on supernatural grounds a material fact, or, conversely, of explaining on mechanical grounds a spiritual fact. His having, over and over again, clearly and sharply expressed this perception—indeed, it was this perception that forced him to resort to the hopeless idea of preëstablished harmony—may well be esteemed to be Leibnitz's special service to metaphysics, though he himself, and his followers, hitherto make that claim rather for those more brilliant speculations. Certain it is that matter, as we have to do with matter in physico-mathematical studies, is not all, not the substance of things. But what there is over and above matter is hidden from us; and when we strive to set up before

our mind's eye objectively a spiritual substance, we simply deny the properties of matter as reported to us by our senses, and hence the product of our phantasy proves incapable of causal action and reaction with matter.

How profoundly in error, then, are they who, often in a tone of scientific pharisaism, lament our blindness in trying to account for the universe without final causes which so easily and so beautifully solve all problems, even those of ethics! These people simply show that at bottom they are ignorant of what knowledge means. For us there is no other knowledge save mechanical knowledge, however beggarly a substitute that may be for true knowledge, and consequently there is only one truly scientific form of thought, the physico-mathematical one. Hence there can be no more mischievous illusion than that whereby we are led to believe that we explain the teleology of organic nature by calling to our aid an immaterial intelligence, conceived in our own likeness, and working for ends. It is of no consequence what form we give to this anthropomorphism; whether with the "Timæus" of Plato we postulate as an emanation of Deity in living beings moving ideas, with which never any definite conception has been connected in anybody's mind; whether with other philosophers we suppose an unconscious soul which constructs bodies after the types of their various kinds ever present to itself, which sees through all the enigmas of physics and chemistry, and which is thus far more intelligent than the conscious soul ; or, finally, whether with Leibnitz we suppose God to have once for all in the beginning ordered the universe with a view to ends. It is, I repeat, of no consequence under which of these forms one attempts the impossible. So soon as one quits the region of mechanical necessity, he enters the boundless cloud-land of speculation. But it is all to no purpose; for, if the teleological character of nature weaves a crown of thorns for monism, at the same time her occasional antiteleology is anything but a bed of roses for dualism. The appeal to the advantages presented by dualism for the explication of ethical problems is of no avail with one who knows the true state of the case. Must we over again be reminded of the obscurity which Leibnitz vainly labored to remove in his "Theodicy"?

The student of nature in the present day can only assume the attitude of resignation toward the ultimate principles of things. I have in another place shown how the palpable errors of such thinkers as Leibnitz can be explained by the times in which they live. Between Leibnitz and ourselves there is an enormous chasm dug by scientific research, reënforced by observation and experiment, by calculation and induction.

Above all, qualitative research, so called, has on the scientific mind an educating influence, like that of life on character. Being corrected at every step by nature, and constantly reminded of the uncertainty of his judgments and the fallaciousness of his apparently most firm con-

clusions; being sooner or later infallibly punished for every over-hasty opinion, for every act of blind trust in appearances: such is the discipline which accustoms the experimental scientist to be chary about rapid and brilliant conquests; to attack the truth which he fain would discover by gradual approaches; to test it as impartially as though his aim were to prove the contrary; and finally, when he is arrived at a number of perhaps mutually contradictory facts held together by a tissue of still obscure relations, and the whole looking toward sundry possibilities whereof experience alone can decide which is stronger, resignedly to keep that state of things present to his mind as the best it is conceded him to know.

Surely it appears as though mathematical research, too, which proceeds inductively to a greater extent than is commonly supposed, might have a like educating effect. It, too, possesses what is lacking to metaphysical speculation, the sure means of determining whether its judgments are correct or not. But the mathematician draws this determination from himself, and hence his occupation is less adapted than experiment for weakening one's trust in speculation. Hence it is that mankind could for two thousand years busy itself about problems in mathematics, without ever curbing their propensity to speculation; hence, again, Descartes and Leibnitz, two of the greatest mathematicians of the seventeenth century, were also the boldest metaphysicians of the same period.

Hardly two centuries have elapsed since chemists, physicists, and physiologists went to work steadily and systematically, and already we see the fruits of their teaching, as transmitted from generation to generation. In this school the human mind has lost the habit of childish reverence and juvenile enthusiasm, grown up to the discretion of manhood, and learned to comport itself modestly in presence of insoluble enigmas. A new phase of its history is observable, partly in the decay of speculativism, and partly in the style of philosophizing now adopted by the best minds.

The practice acquired by the man of science in the small warfare of the laboratory fits him to deal with the great mystery of the universe. The striving which we observe in Leibnitz, toward constructing by hook or by crook a universe wherein preconceptions inherited from the childhood of the race are blended with the insight of an already well-matured physico-mathematical mind, is a thing so foreign to the man of science that he could no more think of adopting that point of view than of adopting the mythological cosmogony of the Hellenes or of the Brahmans. The complacent assurance with which Leibnitz looks on his scheme as demonstrated, reminds him of similar illusions in the beginning of his own scientific development, for in the domain of mind, too, the biogenetic principle holds good. Knowing well how immovably fixed are the bounds set to man's understand-

ing, he has no longing to transcend them. He sees that his field of research lies between the problems, "What are matter and force?" on the one hand, and "How do matter and force think?" on the other; outside of this field he knows only that he knows nothing, can know nothing, and will know nothing. Standing without vertigo on this mountain-summit of Pyrrhonism, he scorns to people the vacuity round about him with the images of his own phantasy and surveys unappalled the unpitying drift of nature without gods. He is not disheartened at the thought that he stands face to face with eternal enigmas. He does not, like an Empedocles, cast himself into the physical abyss whose secrets he is unable to fathom; nor, like a Faust, into the ethical abyss, although no unworthy trammels restrain him from yielding to its temptations. For he contemns not reason and science, though it be denied him to recognize the first cause of things. Like Lessing, he holds the higher good to consist not in the possession but in the pursuit of truth; and therefore does he find solace and exaltation in *labor* which increases the store of human knowledge; which by healthy effort enhances the powers and the capacities of our race, extends our dominion over nature, ennobles our being by enriching our mind, and beautifies it by multiplying our joys.

From the disheartening conclusion, "*Ignorabimus*," the student of nature recovers as he pronounces the stirring countersign given by the dying Septimius Severus to his legionaries—[1]

"*Laboremus!*"

SCIENTIFIC RELATION OF SOCIOLOGY TO BIOLOGY.

BY PROFESSOR JOSEPH LE CONTE.

II.

BIOLOGICAL METHODS APPLICABLE TO SOCIOLOGY.—We have thus shown the use in sociology of the ideas and doctrines characteristic of biology. We have shown that they are applicable, but with some limitations and modifications imposed by the presence of a nature higher than the animal. We come now to show the use of biological *methods* in the cultivation of sociology.

The great characteristic method of biology is the method of comparison. The reason is obvious. The phenomena of life are so complex that it is impossible to reduce them to law without simplifying

[1] Jussit deinde signum tribuno dari *Laboremus*, quia Pertinax quando in imperium adscitus est signum dederat *Militemus*.—"Scriptores Hist. August. ab Hadr. ad Numerianum."

them. But the mode of simplification adopted in physics and chemistry, viz., *experiment*, or the arranging of simple artificial conditions, is only to a slight extent applicable to biology. The phenomena are not only complex, but they are so delicately balanced that the introduction of our rude hands in the way of experiment often overthrows the equilibrium, destroys the conditions of biological experiment, viz., life, and thus throws the whole subject into the realm of chemistry and physics. But, fortunately, nature has prepared for us an elaborate series of experiments. We have organisms of every degree of increasing simplicity, from the body of man to the microscopic spherule of almost unorganized protoplasm called a moner. The complex problem of life, as we go down this scale, is made simpler by the successive removal of added complications, until it is finally reduced to its simplest terms, and thus only we begin to understand the essential phenomena—thus only may we find the value of the unknown quantity. It is, therefore, by extensive comparison of organisms in all stages of complication with each other, that the foundations of a scientific biology have been laid. Anatomy has become scientific only through comparative anatomy; physiology through comparative physiology; and, we may add, psychology is now awaiting the development of comparative psychology.

But this general method of comparison is subdivided into three or four sub-methods. Nature has prepared not only one but three or four series, not identical, not mere duplicates of each other, but varied, yet resembling and illustrating each other. The first of these is the natural history or *taxonomic* series. It consists of the whole series of organisms as they now exist, from the complexly structured mammal to the simple unicelled plant or animal. The second of these is the embryonic or *ontogenic* series. It consists of the successive stages of development of one of the higher animals, from the germ-cell to the mature condition. The third is the geological or *phylogenic* series. It consists of the organisms inhabiting the earth in successive epochs, from the Archæan until now. The fourth is the *pathological* series. It consists of all possible variations from the normal type by monstrosity or by disease. Though much less full than either of the others, it must not be neglected by biologists.

It is wholly by extensive comparison in these four series that biology has recently risen to the rank of a true science. In this great work, the chief credit is due to three men, viz., Cuvier, Agassiz, and Darwin; for these three are the great founders of the comparative method. Cuvier laid the foundations of comparative anatomy and physiology, by comparison in the taxonomic series. Agassiz extended the comparison to the ontogenic and phylogenic series, showed the resemblance between the three, and determined and announced all the *formal* laws of evolution of the organic kingdom as now recognized. Darwin has made the bold and in large measure successful attempt to explain these laws by the operation of secondary causes. If Agassiz may be called the Kepler

of the time universe, Darwin may with some though with much less show of reason be called its Newton. I say with *less* show of reason, for the causes of evolution are yet very imperfectly known.

Now, not only are all these methods applicable to the study of sociology, but all the advance in this science which has taken place in recent times has been the result of their application. For how has sociology been advanced, and must continue to be advanced? 1. By the comparison of social organisms, nations, tribes, etc., as they now exist in different portions of the earth and in different grades and kinds of civilization, with each other, in institutions, habits, customs, forms of government, etc. Is not this the taxonomic series? 2. By comparing the different stages of development of the same social organism, from savagism to the highest degree of civilization, and marking the origin, growth, and modification of government, institutions, customs, etc. Is not this the embryonic or ontogenic series? 3. By comparing with each other the successive stages of advance of *all* social organisms of the whole race through the rude stone, the polished stone, the bronze, and the iron conditions. This is M. Comte's historic method; but is it not the geological or phylogenic series? 4. By comparing the same social organism with itself in its normal and abnormal conditions, i. e., in a state of peace, prosperity, social health, and social sanity, with the same in various states of commotion, revolution, anarchy, social fever, and social frenzy. Is not this the pathological series? It is impossible to doubt that these are the true scientific methods of sociology. But they were all first used in biology, and only afterward imported into sociology.

But it will perhaps be objected: "This supposed relation of sociology to biology is but an *analogy* which has not even the merit of being new or recent. It has always been recognized. It is well expressed by the story told by Menenius Agrippa to the mutinous Roman plebeians, in which he showed the absurdity of their conduct by comparing the condition of Rome to a state of war among the members of the body. It is also admirably expressed by St. Paul in his comparison of the church to a well-organized body with different members having different functions. The analogy has always been recognized, but has not borne any special fruit in the advancement of social science, or the betterment of the social condition." To this I answer: Yes, it has always been recognized; but there are different degrees of recognition, and it is *only the higher degrees which bear any scientific fruit*. In this, as in other departments, a recognition of the laws of nature by the *imagination* gives rise to metaphor, simile, poetry, art, and in its highest manifestations is what we call genius. A *dim*, imperfect recognition of the same by the reason constitutes *analogy*. The clear recognition by the reason of the same in all its details, so that the application of appropriate methods becomes possible, constitutes science. Thus sociology, like

all other sciences, has its three stages: 1. The facts of sociology are collected and recorded in chronicle and history. This is descriptive sociology. 2. These facts are reduced more or less successfully to general formal laws. This is philosophical history, or formal sociology. Thus far sociology is built upon its own basis of facts and phenomena; an analogical connection with biology may have been recognized, but not a scientific connection. 3. These formal laws are connected with and explained by the fundamental laws controlling organisms as their cause, and sociology becomes finally a *causal* science. In this, as in all other sciences, this last step is attended with prodigious impulse and steady advance, for it is this last step which connects it with the hierarchy and gives it the assistance of all other sciences. It is this step which has only recently been made, and its effect is already visible.

But it will be again objected that society is already highly organized; how, then, can it be said that the science of social organization is of recent origin? How could the principles of social organization be embodied without a knowledge of those principles? The answer to this is quite plain, and brings to view an additional resemblance between society and other lower forms of organization. As the organic body passes from lower to higher and still higher forms without any will or consciousness or knowledge of the process on the part of the organism itself—or, still better, because more closely analogous to the social organism, as the organic kingdom, regarded as an organism, throughout all geological times developed into higher conditions without any intention on the part of the many individuals of which it is composed, but only as the natural result of each seeking its own ends in the struggle for life—even so society advances to more and more highly organized conditions without any intention on the part of the individual members, much less any knowledge of the principles of social organization, but purely as the natural result of the struggle for life, and each member seeking his own immediate ends. In both cases it is natural law working out its legitimate result. In both cases it is God (for natural law is the mode of Divine activity) working to a given end without the conscious coöperation of individuals. But there is this wide difference: In the latter case, if the development continues, there inevitably comes a time when man turns about and reflects upon what he has unconsciously or at least intuitively done; there eventually comes a time when he consciously coöperates with God or nature, and strives by the use of reason and science to modify and improve the social organism.

Or, regarding it from a slightly different point of view, the social organism is a work of art, the noblest of all arts. Now *art* always *precedes science*, and not the reverse, as many seem to suppose. It is fortunate that it is so, or emergence from barbarism would be impossible. The art of walking is acquired in great perfection before the principles of equilibrium involved are understood. Handspikes and pulleys and

screws were used before the principles of the lever and inclined plane involved in their use were understood. The art of music was carried to exquisite perfection before the scientific principles of harmony were known. Pottery, agriculture, and many other useful arts were not only practiced, but carried to a high degree of perfection, before the corresponding sciences were born. The capacity for art is inherited from the animal kingdom. Science is born of humanity, and is therefore distinctively human. Art is born of instinct or intuition; science of the conscious reason. Art is the result, at first, of the empirical method; science always of the rational method. I repeat, then, art precedes, leads upward to the comprehension of science; but science, when sufficiently perfect, turns again and perfects art. Art is the earthly mother of science; but the celestial daughter, when mature, turns again and blesses and helps her mother. Even so is it with human society. The art of government and of social organization precedes the corresponding science, and is its necessary condition; but when sufficiently perfect, sociology will undertake to modify and better the social organization, and guide the social development.

But I said, art is inherited from the animal kingdom; science is born of humanity. For this reason art is of itself limited; science is unlimited, for it is connected only with the highest nature of man, the spiritual and eternal. Art may be carried to a high degree of perfection, but unless assisted by science quickly culminates and declines, or else becomes petrified and immutable; but if its principles be understood, if it becomes allied with science, if it passes under the dominion of the self-conscious reason, it then becomes indefinitely progressive. So also that highest art, the art of government and social organization, may reach, unassisted by science, a high degree of perfection; but if it be simply an art it quickly culminates and declines, or else becomes petrified and immutable, as we see in the Chinese and Japanese. As in the organic kingdom each organic form is specialized to the greatest extent and then becomes immutable and generally perishes; as the tree of life branches, and each branch grows its several way—flowers, fruits, and dies—even so each isolated nation, or branch of the social tree, pushes its growth it knows not whither, but as far as possible in its direction, then flowers, fruits, and dies. But if the scientific principles of sociology be once understood, if science or self-conscious reason guide the social development, there can no longer be any limit to its progress. But observe: this indefinite progress is due wholly to the introduction of other principles than those derived from purely animal nature; it violates the perfect analogy to material organisms. In fact science, which determines and guides that indefinite progress, is itself born only of that higher nature.

But again: all who have reflected much on the relation of science to art can not fail to have observed that while a *mature* science guides art with certainty, and continues to perfect it without limit, yet there

is a certain stage in the development of science when its influence may be even disastrous. In the passage from art to science there is a certain stage when the presumptuous application of an *imperfect* science interferes with the truer and better results of a perfect empiricism, and art is thereby hurt. This is true especially of the more complex arts and sciences. Thus the principles of science must be held in subordination to an enlightened empiricism in such arts as medicine, agriculture, etc. Science can not yet undertake to guide these arts with confidence. So is it also, and in a much greater degree, in the case of human society; for here we have the most difficult art, and the most complex and imperfect science. It must be yet a very long time before the science of sociology can presume to guide the course of social progress. Premature interference with the results of an enlightened empiricism can do nothing but harm.

I have now covered the ground which is implied in the title of this article. I have shown the close connection, both in doctrine and method, between social and organic sciences—a connection similar to that which exists between organic science and that immediately below it in the hierarchy. I have shown that sociology is one of that hierarchy, and the highest. I have shown that the cultivation of this science requires acquaintance with all other and simpler sciences, but especially biology. My task would seem to be done. But I would do violence to my feelings and convictions, and would be liable to serious misconstruction, if I stopped here. What I have thus far said gives but an imperfect idea of the comprehensiveness and complexity of social science. I have yet shown but one side of this complex subject, although the side which is most familiar to my thoughts, and, I believe, also the best developed. It is necessary at least to glance at the other side. I have developed *one* of the foundations or basic connections of sociology; but there is another, as I now proceed to show.

All along, in the course of this discussion, I have from time to time shown that there are certain limitations to the application of the doctrines and methods of biology to sociology, and that in every case such limitation is the result of the introduction of some new principle characteristic of *humanity* as distinguished from *animality*, of *reason* as distinguished from *instinct*, of *spirit* as distinguished from *matter*. This is precisely what, even from a purely scientific point of view, we ought to expect, and is in fact necessary. For in the scientific hierarchy each science, in addition to the forces and phenomena of the lower sciences, deals with a new force and a new group of phenomena, and therefore with new doctrines and new methods. In going up the scale of sciences we rise successively to a higher and higher plane of activity. On the plane of dead matter only physical and chemical forces operate, and only physical and chemical phenomena occur. On the plane of living matter, in addition to the preceding, we have also vital forces and

phenomena. On the plane of sentient existence we have, in addition, nerve force and phenomena. On the plane of rational and moral existence we have, in addition to all the preceding, also rational and moral forces and their corresponding phenomena. With every rise to a higher plane we have also, as has already been shown, new doctrines and new characteristic methods. Shall we not, then, on this highest plane also, viz., on the plane of rational and moral existence, the plane of humanity, shall we not have here also new characteristic methods and doctrines connected with this new and higher form of force? It is evident that we must. All the doctrines and methods which I have developed are imported from biology. I have said nothing of characteristic methods and doctrines of sociology. Comte clearly saw the necessity, in accordance with the principles of a scientific hierarchy, of a characteristic method, and he thought he had found it in what he calls the historic method. But Comte's historic method, as we have already shown, is nothing but comparison in the phylogenic series—a method which is imported from geology. There must be characteristic methods and doctrines in this highest science also. What are they? Man is certainly something more than an animal. What is that something more? The answer to these two questions is the same. The characteristic doctrines and methods of sociology are evidently connected with man's higher rational and moral nature—with his distinctive humanity. But the science of this side of our nature is yet so imperfectly developed, our knowledge of these higher phenomena is yet so imperfectly reduced to law, that these characteristic doctrines and methods are not clearly recognized and distinctly formulated. In a word, our knowledge here is not yet scientific; the department has not yet even a distinctive name. For want of a better we shall call it psychology, although it really includes much more than usually goes under that name. But when (if ever) this department of knowledge shall take on a scientific form, then it also must become another basis, another fundamental science, on which must rest sociology. And what sociology is now waiting for, more than for anything else, is the scientific development of this second basis.

Thus then sociology, unlike other sciences, and because of man's twofold nature, rests not on one only but on *two* more fundamental sciences. The basis which I have developed is the material basis. This is all that the materialists admit. If a pure material philosophy were sufficient, this is all the basis which sociology requires. The fact that it is not sufficient, the fact that another basis is required, is demonstrative against a pure material philosophy. According to a pure material philosophy science is a *straight* shaft rising ever until it pierces heaven. But, on the contrary, if we watch its progress closely, we perceive that it indeed rises straight enough *at first;* but as it approaches the plane of humanity it begins to lean and curve to one side, until it inevitably falls over, unless it be supported on that side also. That support which

it must receive is, or should be, the rising and arching shaft of psychology. But, alas! this shaft is yet too imperfectly built to support effectively, and hence the present unsteady condition of the whole fabric of science so far as it relates to man.

Thus, then, there are two fundamental sciences upon which sociology must rest. These are on the material side biology and on the spiritual side psychology. But sociology, like all other sciences, must first rise on its own basis of observed and collated facts and phenomena. Therefore we may describe the process of the building of a scientific sociology as follows: First, social facts, or building materials, are gathered in chronicles and detailed histories: this is descriptive sociology. Then these facts are collated and reduced to laws, the materials are chiseled and fitted and cemented into a rising column: this is formal sociology, or philosophic history and political economy. Then the column arches and connects in one direction with the more fundamental science of biology, and in another direction with that of psychology, and thus becomes causal or true scientific sociology. On this triune arch (not double arch, for the columns stand in triangle) rests the broad triply-supported platform of social science, and from this must hereafter rise the beautiful shaft of increasing social knowledge.

On this triply-supported platform there are *three regions* from which spring respectively three shafts, distinct yet united to form one. The social organism is composed of three subordinate organisms; the social body is composed of *three fundamental coördinate corporations*, connected each most closely with one of the supporting columns. These are—1. The political organization; 2. The moral and religious organization; and, 3. The industrial organization: or the *state*, the *church*, and the *guild*. The first is connected directly with the *history* column; the second with the *psychology* column; and the third with the *scientific* column. They may be compared (though the comparison may be considered fanciful) to the three great regions of the organic body, viz., the *head*, the *thorax*, and the *abdomen*, or rather to the three great coördinate systems of the animal organism, viz., the nervous system, the blood and respiratory system, and the digestive system; the first controlling and directing, the second warming and vivifying, the third furnishing aliment. They correspond also to the three great divisions of the psyche, viz., the intellect, the affections, the will: the first directing and controlling; the second giving motive-stimulus, energy; the third, active and executive. They correspond finally to the three subordinate and coördinate courses of a perfect human culture insisted upon in my article "On Liberal Education,"[1] viz.: 1. The *Language-Art* course, commencing with language, ancient and modern, passing upward through literature, art, history, philosophical history, and thus connecting with sociology through the political organization or the state; 2. The *Philosophic* course, commencing with logic and passing

[1] "Southern Presbyterian Review," 1859.

upward through mental philosophy, moral philosophy, and so connecting again with sociology through the religious organization, the church; 3. The *Scientific* course, commencing with mathematics and passing up through the hierarchy of science, as already given, and so connecting again with sociology through the industrial organization, the guild.

I have made only three fundamental corporations of the social organism. Friedrich Schlegel, the celebrated writer on philosophy of history, in a series of articles entitled "Characteristics of the Age," makes five essential corporations rising one above the other in the following order, viz., the family, the guild, the state, the school, the church. But the least reflection, I think, will show that the family and the school belong to a different order from the other three, being *subordinate* and preparatory to them, not *coördinate* with them. The former are *internal, elaborative;* the latter external, visible, public, final results. I am sure that the more we reflect upon this subject, the more we will be convinced that there are only three fundamental and strictly coördinate corporations.

We have seen that it is the guild which is most directly and closely connected with the scientific column, and with our material nature. In accordance with this fact we find that it is this sub-organism which is by far the most perfectly organized. It is in this that we see most perfectly carried out the law of differentiation and specialization of social functions and mutual dependence of parts; and the strongest tendency to identification of the individual life with the social function. In other words, it is precisely here, as we should expect, that we find the nearest approach to the ideal of material organization. In accordance with the same fact we also find that the corresponding department of social science, viz., political economy, is that which is by far the most perfectly developed.

There are three mistakes made by thinkers on the subject of sociology, all founded on a too limited view of the structure of the social organism, each consisting of an attempt to absorb the whole organism into one of the fundamental corporations—to regard the great field of sociology as connected with only one of the supporting columns mentioned above. Lawyers, politicians, statesmen, and indeed people generally, regard sociology as most closely connected with the history column, and would make the state paramount. The state is for them the social organism. Theologians and moralists, on the other hand, would make the church paramount in importance if not absolutely absorbing the others, and sociology as most closely connected with the psychology column. The modern materialist would make the guild the paramount corporation, and sociology as most closely connected through biology with the scientific column. The political philosopher is apt, therefore, to cling only to empirical laws and so-called practical methods, unaware of or denying the connection of sociology with any more fundamental departments of science, and especially its connection with

biology. The psychologist and the theologian are apt to ignore too much the material basis of sociology, the organic laws which through our material nature impress themselves upon the structure and development of society; while the materialist and the political economist are apt to overlook or belittle the importance of the other essential corporations, especially the church, and make sociology nothing more than the highest of the material sciences. But no steady, safe progress in social organization can be made unless we fully recognize the coördinate value of these three, nor in the science of sociology unless we approach the subject from these three sides.

THE CRYSTALLIZATION OF GOLD, SILVER, AND OTHER METALS.

By THOMAS J. GREGAN.

THERE are few chemical experiments so well known as the growth of the "lead-tree" and "silver-tree." These carry our minds back to the times of the alchemists, who called the first "Arbor Saturni," and the second "Arbor Dianæ," and they may be looked upon as the type of a large number of phenomena in which the salt of one metal in solution is decomposed by some other metal.

My assistant, Dr. Hand, and myself have lately been experimenting on these replacements, the metallic crystals which are thus produced, and the forces that act through the liquid. Our more special attention has been given to the mutual action of copper and nitrate of silver. If these two substances be brought into contact by the intervention of water, there grows on the red metal what may be called "trees," and, though the analogy between the crystals and the plants is a very superficial one, still the resemblances of external form are sufficiently striking, and a nomenclature drawn from the garden seems the most expressive.

A microscopic view of the growth of these silver crystals round a piece of copper is a truly beautiful sight; a blue glass underneath increases the effect, but they are best seen when they reflect a strong light thrown upon them. They may also be thrown upon a screen as opaque objects, but the beauty and luster of their surfaces are in this way lost. The crystals of silver thus produced differ both in color and form according to the strength of the solution. If it be very weak—say one per cent.—the copper is fringed with black bushes of the metal, which in growing change color to white without any alteration of crystalline form that can be detected by a powerful microscope. A stronger solution gives white crystals from the commencement, which frequently

assume the appearance of fern-leaves; while the growth from a still stronger liquid reminds us rather of a furze-bush. If the nitrate of silver amount to fifteen per cent. or thereabouts, there occurs a steady advance of brilliantly white moss ; and, if the solution be saturated, or nearly so—say forty per cent.—this moss is very sturdy, often ending in solid crystalline knobs, or stretching out into the liquid as an arborescent fringe.

In all these cases, however, when the solution in front of the growing crystals has been somewhat exhausted, certain prominent or well-circumstanced crystals seem to monopolize the power, and to push forward through the remaining portions of the liquid. This raises beautiful branches which assume a variety of graceful forms, which it is hopeless to attempt to portray by diagrams, but the subjoined figures give some of the more characteristic outlines greatly magnified. The weak solutions produce feathery crystals, as somewhat in Fig. 1, consisting of

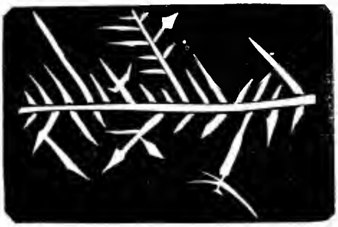


FIG. 1.

FIG. 2.

a straight central stem from which grow on either side crystalline rays that terminate in a sharp point, and frequently become themselves the center stem of a similar crystalline structure.

In the outlying growth of a moderately strong solution the apparent regularity of the crystalline form is lost ; the main stem is built of a confused mass of hexagonal plates, while the side branches are an agglomeration of minute pointed crystals turning in every direction, and producing such jagged outlines as in Fig 2.

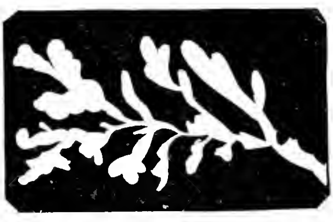


FIG. 3.

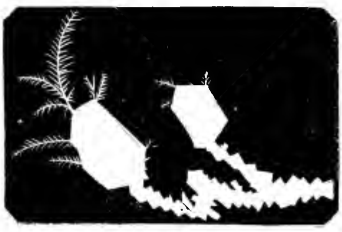


FIG. 4.

In still stronger solutions the branches lose every appearance of straightness, and they are built of hexagonal plates so studded with

crystalline specks that the whole has the rounded appearance as in Fig. 3. The arborescent crystals that succeed the fringes, from a saturated solution, are smaller in their foliage than the last, and end in small spherical or botryoidal knobs.

Besides these various forms, there occur all kinds of crystalline combinations, as for instance the spray sketched in Fig. 4, when the long and rough branches have terminated each in a large hexagonal plate and the flowing past of a weak solution has afterward caused the growth of delicate fern-leaves. Often, also, a large expansion will take place in every direction, though joined to the parent stem by an almost invisible thread; or, from the point of a long crystal there will branch out to right and left crescent-shaped structures, a process the commencement of which is seen in one of the side rays of Fig. 1. The last traces of silver will frequently give rise to delicate crystalline filaments wandering over the surface of the glass, as in Fig. 5.

Fig. 5.

If a piece of zinc be placed in a solution of neutral terchloride of gold, containing about nine per cent. of salt, there is an immediate outgrowth of black gold, which speedily changes to an advancing mass of yellow or perhaps lilac metal of lichen-like forms, from which proceed beautiful fringes of yellow or black, ending generally in such

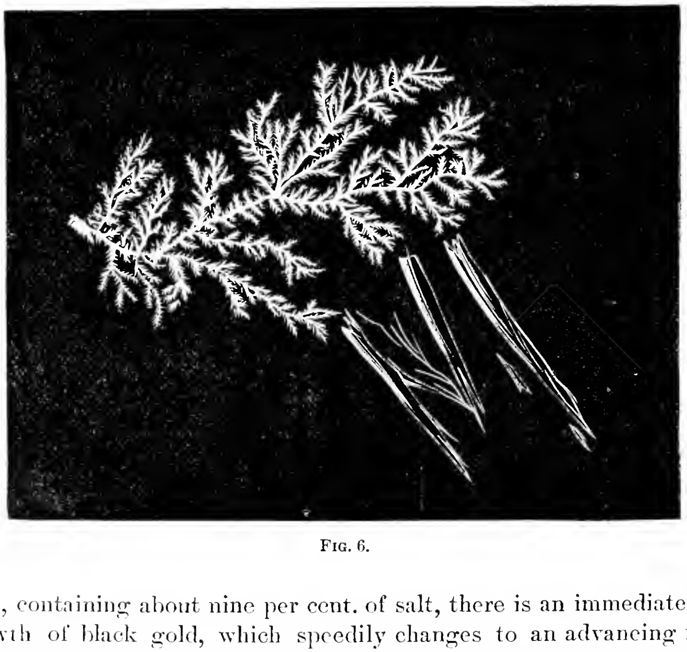


Fig. 6.

arborescent forms as are represented in Fig. 6. As these branches push into the yellow liquid, it becomes colorless even in advance of their points, and it frequently happens that yellow crystals of some salt shoot out in front of the crystallizing metal, which follows them and builds up its advancing fronds at their expense. This is shown in the figure. The gold will generally shoot its yellow branches rapidly round the margin of the drop. Such a running branch has been seen to stop on coming in contact with a loose piece of gold, which immediately in its turn becomes active, and commences to sprout on its farther side. Copper salts give round nodules, which have no crystalline appearance when deposited from moderately weak solutions, but a very strong solution of the chloride—about forty per cent.—yields with zinc, first a thick, black growth, then arborescent fringes of red metal, terminating in crystals of very appreciable size.

The fringes referred to in the case of these three metals are still more characteristically developed by bismuth. When a solution of the terchloride of bismuth acts on zinc there is an immediate outgrowth of black fringes, as in Fig. 7, where they are seen on an illuminated field. As they advance, these become more arborescent, and as the crystalline character becomes more developed they change from black to gray. Sometimes bismuth presents itself in botryoidal masses, but the tendency to form the fringes is very strong.

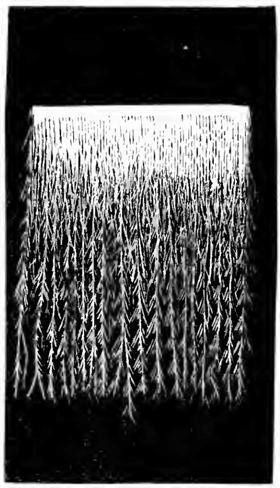


FIG. 7.

Chloride of antimony with zinc also gives black fringes. Lead salts yield crystals resembling those of silver, but leaves of irregular, hexagonal plates prevail, and frequently become of large size.

A solution of acetate of thallium, of twenty per cent. of salt, quickly gives a beautiful forest of thorny crystals. Sulphate of cadmium gives rise to a small, leaf-like growth on zinc; but a strong solution of the chloride produces an appearance of sticks covered with small spines or knobs. The new metal indium is thrown down upon zinc in the form of thick, white crystals. The deposition is promoted by touching the zinc with a piece of iron.

Tin gives beautiful results. If zinc be placed in a solution of stannous chloride it is quickly surrounded with a growth of prolonged octohedra, and as these advance into the liquid it is easy to observe that the additions of new metal commence at the apex, and that the wave of chemical change proceeds down the lateral edge, occupying some seconds of time in depositing the new layer of material. Frequently,

also, there is a luxuriant growth of large, flat leaflets, or symmetrical structures resembling fern-leaves, but with the fronds arranged at right angles, or combinations of these with octohedra, as shown in Fig. 8. These fern-leaves often begin of a dull-gray color, but, as they advance, suddenly change to a brilliant white. The particular form of these crystalline growths depends, therefore, primarily on the specific character of the metal, but this is greatly modified by the strength of the solution.

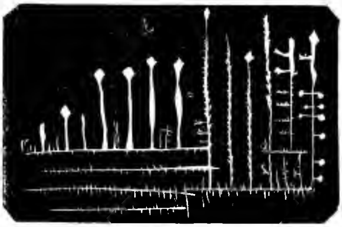


FIG. 8.

The forms assumed by native metals resemble those produced by the process of substitution. In some cases, indeed, it seems almost certain that the deposition of these minerals was effected in the same way—as, for instance, the silver on the native copper of the Lake Superior district.

Gold is frequently found in cubes more or less rolled, but the leaf-gold from Transylvania bears a striking likeness to the crystals that form in our laboratory experiments.

Silver is often found native as twisted hairs or wires of metal—a form that never occurs in the decomposition of its nitrate by copper, but which can be artificially produced in another way. There has been noticed a singular tendency in old silver ornaments and coins to become crystalline and friable. I have an ancient fibula from the island of Cyprus, supposed to be at least fifteen hundred years old, which, through the greater portion of its substance, presents a fracture something like that of cast iron, and its specific gravity has been reduced in round numbers from ten to nine.

It contains a little copper. This property of certain metals, or their alloys, to change in condition and in volume, is worthy the attention of those whose duty it is to make our standards. Experiments should be instituted for the purpose of learning what metals or combinations of metals are least subject to this secular change.

These metallic crystals are Nature's first attempt at building. The material is the simplest possible—in fact, what chemists look upon as elementary. But how is the building carried on? What are the tools employed? Where are the bearers of burdens that bring and prepare the pieces and lay them together according to the plan of the Great Architect? We must imagine what is taking place in the transparent solution. The silver, of course, existed at first in combination with the nitric element, and for every particle of silver deposited on the growing tree an equivalent particle of copper is dissolved from the surface of the plate. The nitric element never ceases to be in combination with a metal, but is transferred from the one metal to the other. On the "polarization theory" the positive and negative elements of

the salt constantly change places and enter into fresh combination, one consequence of which would be a gradual passage of the nitric element from the growing silver to the copper plate. This actually takes place, and there is a diminution of the salt at the ends of the silver branches, giving rise to an upward current and a condensation of nitrate of copper against the copper plate, which gives rise to a downward current. These two currents are seen in every reaction of this nature. In the case of silver and copper, however, it has been proved that the crowding of the salt toward the copper plate is more rapid than would follow in the usual "polarization theory." The instrument used in determining this point was a divided cell in which two plates, one of silver and one of copper, connected with a wire, are each immersed in a solution of its own nitrate, contained in each division of the cell, and separated merely by parchment paper. The crystals of silver deposited on the silver plate in this experiment are very brilliant. There are indications of the liquid being put into a special condition by the presence of two metals which touch one another. Zinc alone is incapable of decomposing pure water, but if copper or platinum be deposited on the zinc in such manner that the water can have free access to the junction of the two metals, a decomposition is effected ; oxide of zinc is formed and hydrogen gas is evolved. At ordinary temperature the bubbles of gas rise slowly through the liquid, but, if the whole be placed in a flask and heated, pure hydrogen is given off in large quantity. We have also found that iron or lead similarly brought into intimate union with a more electro-negative metal, and well washed, will decompose in pure water.

As might be expected, the action of magnesium on water may be greatly enhanced by this method ; and a pretty and instructive experiment may be made by placing a coil of magnesium in pure water at the ordinary temperature, when there will be scarcely any visible effect, and, then adding a solution of sulphate of copper, the magnesium is instantly covered with a growth of the other metals, and at the same time the liquid seems to boil with the rapid evolution of the hydrogen-bubbles from the decomposed water.

When, however, the force of the two metals in contact has to traverse a layer of water, the resistence offered by the fluid prevents its decomposition. This must also be an important element in the decomposition of a metallic salt dissolved in water—and, in fact, we have found that the addition of some neutral salt, such as nitrate of potassium, increases the action, apparently by diminishing the resistance of the liquid. If, too, we increase the quantity of the dissolved salt, we get more than a proportional increase of deposited metal. Thus, in an experiment made with different strengths of nitrate of silver, the following results were obtained in ten minutes, all the circumstances being the same except the strength of the solution:

1 per cent.	solution,	0259	copper.
2 "	"	078	"
4 "	"	224	"

In fact, it has been found that, in solutions not exceeding five per cent., twice the amount of nitrate of silver dissolved in water gives three times the amount of chemical action; and this is true with other metals also in weak solution. It may be that this is not the precise expression of a physical law, but it agrees at least closely with the results of experiment.

The power arising from this action of two metals on a binary liquid may be carried to a distance and produce similar decompositions there. This is ordinary electrolysis. Metals have often been crystallized from their solutions in this way, and I have seen excellent preparations of crystalline silver, gold, tin, copper, platinum, etc., by using poles of the same metal as that intended to be deposited upon them. The forms thus obtained are precisely analogous to those produced by the simple immersion of one metal into a soluble salt of another, and illustrate still further the essential unity of the force that originates the two classes of phenomena.

HERBERT SPENCER BEFORE THE ENGLISH COPYRIGHT COMMISSION.[1]

II.

QUESTION (*Chairman*). I will ask you if you have any explanations you wish to offer on any point connected with the evidence which you gave on the last occasion?

Answer. Yes; I have to rectify some misapprehensions. From the restatement made by Mr. Farrar, it would appear that, in discussing the question of profits from republication of one of my works, I said I had "found that no other publisher would undertake the work without an additional profit of ten per cent.," which implies that I had endeavored to obtain another publisher. My meaning was, that I ascertained that any other publisher who thought of issuing a rival edition would expect to make a profit of ten per cent. beyond the ten per cent. commission for doing the business. Further, I have to remark that the case I took as illustrating the improbability that I should obtain any considerable compensation from increased sales under the royalty system was the case of one of my works only, the "Principles of Psychology," and in respect of this I may admit that there would be little danger of a rival

[1] March 20, 1877: Lord John Manners, M. P., in the chair. Present, Sir Henry T. Holland, Sir Louis Mallet, Dr. William Smith, Anthony Trollope; J. Leybourn Goddard, Esq., Secretary.

edition. But it is not so with others of my works—with the work on "Education," now in its fourth thousand; with "First Principles," now in its fourth thousand; and especially with the just-issued first volume of the "Principles of Sociology." These are now sufficiently in demand, and, especially the last, sufficiently popular in manner and matter, to make rival editions quite probable.

Q. Now, with respect to the stereotype plates, would they not enable you to exclude the rival editions of which you speak?

A. I think not. In the first place, the assumption that other publishers would be deterred from issuing rival editions by my stereotype plates, implies that other publishers would know I had them. I do not see how other publishers are to know it, until after I had myself printed new editions—even English publishers—and it is out of the question that colonial publishers should know it. Hence, therefore, the fact of my having stereotype plates would not prevent such rival editions. Consequently these rival editions, making their appearance unawares, would compete with my existing stock, printed in a comparatively expensive style, and would oblige me either to sacrifice that stock or to lower the price to one far less remunerative. Then, subsequently, there would not be the supposed ability to compete so advantageously with editions published by others. An edition to be sold at a cheap rate must not be in large type, well spaced, and with ample margins, but must be in small type, and much matter put into the page. Hence the existing stereotype plates, adapted for printing only books in a superior style, could not be used to print cheap books: the quantity of paper and the cost of printing would be much larger items than to one who arranged the matter fitly for a cheap edition.

Q. Then we are to gather that you do not think that from any such cheap edition you would derive a profit from the royalty compensating you for your loss?

A. Nothing like compensating. Although the sales of these more readable books I have instanced might be considerably increased, the increase could not be anything like as great as would be required to produce the return I now have. Even supposing the price of the rival edition were the same, which of course it would not be, the ten per cent. royalty would bring in the same amount, only supposing four times the number were sold that I sell now; and as, by the hypothesis, the price of the volume, to get any such larger sale, must be much lower, the royalty would bring in so much the less. If, say, "First Principles" were issued at half the present price, eight thousand would have to be sold instead of one thousand, to bring in by royalty the present returns. Such an increase of the sale would be out of the question; even one half of it would be improbable; so that certainly one half of my returns would be lost.

Q. Have you any other personal experience that you wish to bring before the commission to show that such a modification of the copy-

right law as you have been discussing would be disadvantageous to literature of the graver kind?

A. I think I have. "First Principles" was published in 1862, and in the course of some years the doctrine it contains underwent, in my mind, a considerable further development, and I found it needful to reorganize the book. I spent five months in doing this; canceled a large number of the stereotype plates; and was thus at considerable cost of time and money. As I have already pointed out, the work being now in its fourth thousand, has had a degree of success such that there might, under the proposed arrangement, very possibly have been a rival edition at the time I proposed to make these alterations. Had there been such a rival edition, this cost of reorganization to me would have been more serious even than it was; since the difference between the original and the improved edition, adequately known only to those who bought the improved edition, would not have prevented the sale of the rival edition; and the sale of the improved edition would have greatly diminished. In any case the errors of the first edition would have been more widely spread; and, in the absence of ability to bear considerable loss, it would have been needful to let them go and become permanent. A kindred tendency to the arrest of improvements would occur with all scientific books and all books of the higher kind, treating of subjects in a state of growth.

Q. With the object of rendering useful books as accessible as possible to the public, do you think that those engaged in their production and distribution should be restrained from making what might be called undue profits?

A. In answer to the first part of the question I hope to say something presently, showing that the advantage of increased accessibility of books is by no means unqualified; since greater accessibility may be a mischief, if it tells in favor of worthless books instead of valuable books. But, passing this for the present, I would comment on the proposition, which I perceive has been made before the commission, that it is desirable to secure for books "the cheapest possible price consistent with a fair profit to those concerned." I here venture to draw a parallel. What is now thought so desirable respecting books was in old times thought desirable respecting food—"the cheapest possible price consistent with a fair profit to those concerned." And to secure this all-essential advantage, more peremptory, indeed, than that now to be secured, there were regulations of various kinds extending through centuries—alike in England and on the Continent—forbidding of exports, removing of middlemen, punishing of forestallers. But I need hardly recall the fact that all these attempts to interfere with the ordinary course of trade failed, and after doing much mischief were abolished. The attempt to secure cheap books by legislative arrangements seems to me nothing less than a return to the long-abandoned system of trade regulations; and is allied to the fixing of rates of interest, of prices,

of wages. In the past it was the greediness of money-lenders that had to be checked, or, as in France for many generations, the greediness of hotel-keepers; and now it appears to be the greediness of book-producers that needs checking. I do not see, however, any reason for believing that, regulations made by law to secure cheap bread for the body having failed, there is likelihood of success for regulations aiming to secure cheap bread for the mind.

Q. Then do we understand you to mean that no analogy furnished by past experience in commercial affairs can be held to imply that the proposed royalty plan would succeed?

A. I think that all the facts are against it. I find it stated in the evidence lately given that there has not been raised "an insuperable objection in point of principle" to the plan of a royalty. If no such objection in point of principle has been raised, I think one may be raised; the objection, namely, that it is distinctly opposed to the principles of free trade. One of the aims of the plan, as expressed in the words of the same witness, is the "preservation of a fair profit to the author." Now, on the face of it, it seems to me that any proposal to secure fair profits by legislation is entirely at variance with free-trade principles, which imply that profits are to be determined by the ordinary course of business. But, further, I would point out that, if it is competent for the legislature to say what is a "fair profit to the author," I do not see why it is not competent for the legislature to say what is a fair profit to the publisher: indeed, I may say that it is not only as competent but much more competent. I take it to be impossible for the legislature to fix with anything like equity the profit of authors, if profit is to bear any relation to either skill or labor, as it should do; inasmuch as one author puts into a page of his book ten times as much skill as another, and, in other cases, ten times as much labor as another. Hence, therefore, if they are to be paid at the same percentage on the price, there is no proportion in that case secured between the value of the labor and what they receive. Similarly, if we consider the numbers sold, the royalty which might afford ample return to an author who sold a popular book in large numbers would afford little return to an author who produced a grave book selling in small numbers. Obviously, then, it is extremely difficult, and in fact impossible, for the legislature to fix an equitable royalty; but it is by no means so difficult for the legislature to fix an equitable rate of profit for the publisher. The function of the publisher is a comparatively mechanical and uniform function: the same practically for all books, the same for all publishers, and hence is a thing very much easier to estimate in respect of the proportion; and in fact we have the evidence that it can be fixed with something like fairness, inasmuch as publishers themselves voluntarily accept a ten per cent. commission. Hence, I say, not only does the carrying out of the principle imply that if, in pursuit of alleged public advantage, the profit of the author should be

fixed, then also should the profit of the publisher be fixed, but that it is much easier to do the last than to do the first. If so, then, it is competent for the legislature to go a step further. If there is to be a Government officer to issue royalty stamps, there may as well be a Government officer to whom a publisher shall take his printers' bills, and who adding to these the trade allowances, authors' ten per cent royalty, and publishers' ten per cent. commission, shall tell him at what price he may advertise the book. This is the logical issue of the plan; and this is not free trade.

Q. (*Sir H. Holland*). You will hardly contend that the system of royalty is less in accord with free trade than the existing system of monopoly; you will not carry it so far as that, will you?

A. I do not admit the propriety of the word "monopoly."

Q. Without using the word "monopoly," let me say, than the present system of copyright for a certain term of years?

A. I regard that as just as much coming within the limits of free trade as I hold the possession, or monopoly, of any other kind of property to be consistent with free trade. There are people who call the capitalist a monopolist: many working-men do that. I do not think he is rightly so called; and similarly if it is alleged that the author's claim to the product of his brain-work is a monopoly, I do not admit it to be a monopoly. I regard both the term "free trade" as applied to the unrestrained issue of rival editions and the term "monopoly" as applied to the author's copyright as question-begging terms.

Q. Without saying what opinion I hold upon the point, and avoiding the use of the words "monopoly" and "free trade," I wish to know whether you think it most consistent with the doctrines of political economy that every person should be able, upon payment, to publish a particular book, or that only one person should have it in his power to do so for a certain time?

A. Every person is allowed and perfectly free to publish a book on any subject. An author has no monopoly of a subject. An author writes a novel; another man may write a novel. An author writes a book on geology; another man may write a book on geology. He no more monopolizes the subject than any trader who buys raw material and shapes it into an article of trade is a monopolist. There is more raw material which another man may buy. The only thing that the author claims is, that part of the value of the article which has been given to it by his shaping process; which is what any artisan does. The way in which this position of authors is spoken of as "monopoly" reminds me of the doctrine of Proudhon—"Property is robbery." You may give a stigma to a thing by attaching to it a name not in the least appropriate.

Q. (*Mr. Trollope*). I understand your objection to a system of royalties to be this, that no possible *quota* that could be fixed would be a just payment for all works?

A. That is one objection. There is no possibility of fixing one that would apply to all works, inasmuch as the thing paid for is an extremely variable thing, more variable than in almost any other occupation.

Q. I put that question to another witness before you, but I am afraid failed to make him understand me. I am therefore glad to have the answer from you, in order that we may show (I think you will agree with me) that no special royalty specified by act of Parliament could be just to poetry, and to the drama, and to fiction, and to science, and to history at the same time?

A. Quite so. I think it is obvious, when it is put clearly, that it can not be; and that is an all-essential objection.

Q. (*Sir H. Holland*). Nor would it in your opinion be desirable that the question of determining what amount of royalty is proper in each case should be vested in some registrar or some single person?

A. It would make the matter still worse. It would be bad to vest it anywhere, but especially bad to vest it in any single official.

Q. (*Chairman*). Are we to assume that you think the plan of a royalty to be at variance with the established principles of the science of political economy?

A. I think quite at variance with the principles of political economy. The proposal is to benefit the consumer of books by cheapening books. A measure effecting this will either change, or will not change, the returns of those engaged in producing books. That it will change them may be taken as certain: the chances are infinity to one against such a system leaving the returns as they are. What will the change be? Either to increase or decrease those returns. Is it said that by this regulation the returns to producers of books will be increased, and that they only require forcing to issue cheaper editions, to reap greater profit themselves, at the same time that they benefit the public? Then the proposition is that book-producers and distributors do not understand their business, but require to be instructed by the state how to carry it on more advantageously. Few will, I think, deliberately assert this. There is, then, the other alternative: the returns will be decreased. At whose expense decreased—printers', authors', or publishers'? Not at the expense of the printers: competition keeps down their profits at the normal level. Scarcely at the cost of the authors; for abundant evidence has shown that, on the average, authors' profits are extremely small. Were there no other motive for authorship than money-getting, there would be very few authors. Clearly, then, the reduction of returns is to be at the cost of the publisher. The assumption is that, for some reason or other, the publishing business, unlike any other business, needs its returns regulated by law. Thinking, apparently, of prosperous publishers only, and forgetting that there are many who make but moderate incomes and very many who fail, and thinking only of books which sell largely, while forgetting that very many books bring no profits and still more entail loss, it is assumed that the publishing

business, notwithstanding the competition among publishers, is abnormally profitable. This seems to me a remarkable assumption. Embarking in the business of publishing, like embarking in any other business, is determined partly by the relative attractiveness of the occupation and partly by the promised returns of capital. There is no reason to think that the occupation of publishing differs widely from other occupations in attractiveness; and hence we must say that, competing for recruits with many other businesses, it must on the average offer a like return on capital. Were it found that the average return on capital in publishing was larger than in other businesses, there would immediately be more publishers, and competition would lower the returns. If, then, we must infer that, taking the returns of all publishers on the average of books, their profits are not higher than those of other businesses, what would be the effect of such a measure as that proposed, if, as anticipated, it lowered publishers' returns? Simply that it would drive away a certain amount of capital out of the publishing business into more remunerative businesses. Competition among publishers would decrease; and, as competition decreased, their profits would begin to rise again, until, by and by, after a sufficient amount of perturbation and bankruptcy, there would be a return to the ordinary rates of profit on capital, and the proposed benefit to the public at the cost of publishers would disappear.

Q. Then, with a view to the permanent cheapening of books, we may gather that your opinion is that it would not be effected in the way suggested?

A. I think not. The natural cheapening of books is beneficial; the artificial cheapening is mischievous.

Q. May I ask you to explain what you mean by contrasting the natural and the artificial cheapening of books?

A. By natural cheapening I mean that lowering of prices which follows increase of demand. I see no reason, *a priori*, for supposing that publishers differ from other traders in their readiness to cater for a larger public, if they see their way to making a profit by so doing; and, *a posteriori*, there is abundant proof that they do this. The various series of cheap books, bringing down even the whole of Shakespeare to a shilling, and all Byron to a shilling, and each of Scott's novels to sixpence, sufficiently prove that prices will be lowered in the publishing trade if the market is adequately extensive, just as in any other trade. If it be said that in this case authors have not to be paid, I would simply refer to such a series as that of Mr. Bohn, who, notwithstanding the payments to translators and others, published numerous valuable books at low rates. Moreover, we have conclusive evidence that with the works of still living authors the same thing happens, when the market becomes sufficiently large to make a low price profitable. Witness not only the cheap editions of many modern novels, but the cheap editions even of Mr. Carlyle's works and Mr. Mill's works. Deductively and induc-

tively, then, we may say that there is a natural cheapening of books, going as far as trade-profits allow; as there is a natural cheapening of other things. Conversely, I mean by artificial cheapening, that kind which is anticipated from the measure proposed; for it is expected by means of this measure to make publishers issue books at lower rates than they otherwise do. And this is essentially a proposal to make them publish at a relative loss. If, as already argued, the average rates of publishers' profits are not above those of ordinary business-profits, these measures for lowering their prices must either drive them out of the business or be inoperative. To put the point briefly—if there is an obvious profit to be obtained, publishers will lower their prices of their own accord; and the proposed competitive system will not make profits obvious where they were not so before.

Q. But if there was free competition on the payment of the author's royalty, might it not be that another publisher would be led to issue a cheap edition when the original publisher would not?

A. I see no reason to think this. The assumption appears to be that everybody but author and original publisher can see the advantage of a cheap edition, but that author and original publisher are blind. Contrariwise, it seems to me that the original producers of the book are those best enabled to say when a cheap edition will answer. The original producers of the book know all the data—number sold, cost, return, etc.; and can judge of the probable demand. Another publisher is in the dark, and it does not seem a reasonable proposition that the publisher who is in the dark can best estimate the remunerativeness of a cheap edition. If it is hoped that, being in the dark, he may rashly venture, and the public may so profit, then the hope is that he may be tempted into a losing business. But the public can not profit in the long run by losing businesses.

Q. (*Sir H. Holland*). Take the "Life of Lord Macaulay"; you know that Tauchnitz has published a cheap edition in four volumes—a very neat edition, good paper and good print. Is it not possible that if this system of royalty is introduced, without considering whether the author would lose by it, a cheap edition like that would be put upon the market at once, and would pay the publisher?

A. It is possible that it would be done earlier than it is now done. I take it that the normal course of things is that, first of all, the dear edition should be published and have its sale, and supply its market, and that then, when that sale has flagged, there should come the aim to supply a wider market by publishing a cheap edition.

Q. You are aware that one of the advantages which the advocates of this royalty system most strongly dwell upon is that under the present system the great mass of the reading public are not able to purchase the books; those who have the advantage of circulating libraries can get them and read them, but poorer persons can neither purchase nor read them, whereas under the other system an edition like Tauch-

nitz's would be at once put out, and it is contended that this, though it might be a loss to the author, would be a benefit to the public?

A. Then I take it that the proposal really amounts to this: that whereas, at present, the poorer class of readers are inconvenienced by having to wait for a cheap edition a certain number of years, they shall, by this arrangement, be advantaged by having a cheap edition forthwith; which is to say that people with smaller amounts of money shall have no disadvantages from their smaller amounts of money. It is communistic practically—it is simply equalizing the advantages of wealth and poverty.

Q. (*Chairman*). Then we may assume that in your opinion the royalty system would not operate in cheapening books in the long run?

A. I think that in the first place, supposing it should act in the manner intended, by producing rival editions, it would act in cheapening just that class of books which it would be a mischief to cheapen. I have already intimated, in a previous reply, that the alleged advantage of cheapening books is to be taken with a qualification; inasmuch as there is a cheapening which is beneficial and a cheapening which is injurious. And I have got, I think, pretty clear evidence that the class of books cheapened would be a class which it is undesirable to cheapen. Being one of the committee of the London Library, I have some facilities for obtaining evidence with regard to the circulation of various classes of books; and I have got the librarian to draw me up what he entitles—"Recorded circulation of the following books during the three years following their introduction into the London Library." Here, in the first place, is a book of science—Lyell's "Principles of Geology"; that went out twenty-eight times. Here, on the other hand, is a sensational book—Dixon's "Spiritual Wives"; that went out one hundred and twenty times. Here, again, is a highly instructive book—Maine's "Ancient Law"; that went out twenty-nine times. Here is a book of tittle-tattle about old times—"Her Majesty's Tower"; that went out one hundred and twenty-seven times. Here, again, is another book of valuable inquiry—Lecky's "European Morals"; that went out twenty-three times. Here is a book of gossip—Crabb Robinson's "Diary"; that went out one hundred and fifty-four times. Lecky's "History of Rationalism" went out thirteen times; Greville's "Memoirs" went out one hundred and sixteen times. Herschel's "Astronomy" went out twenty-five times; Jesse's "George III." went out sixty-seven times. I have added together these contrasted results, and the grave, instructive books, taken altogether, number one hundred and eighteen issues, while the sensational and gossiping books number five hundred and eighty-four issues; that is to say, more than five times the number of issues. Now, the London Library is, among circulating libraries at least, the one which is of all the highest in respect of the quality of its readers: it is the library of the *élite* of London. If, then, we see that there go out to these readers five times as many of these books

which minister to the craving for excitement, and are really dissipating books, as there go out the grave, serious, instructive books, we may judge what will be the proportion of demand for such books in the public at large. Now let us ask what a publisher will do in face of these facts. He knows what these demands are, and he has to choose what books he will reprint. A publisher who has laid himself out for rival editions is comparatively unlikely to choose one of the really valuable books, which needs more circulating. I will not say he will never do it. He will do it sometimes; but he will be far more likely to choose one of these books appealing to a numerous public, and of which a cheap edition will sell largely. Hence, therefore, the obvious result will be to multiply these books of an inferior kind. Now, already that class of books is detrimentally large: already books that are bad in art, bad in tone, bad in substance, come pouring out from the press in such torrents as to very much submerge the really instructive books; and this measure would have the effect of making that torrent still greater, and of still more submerging the really instructive books. Therefore, I hold that, if the stimulus to rival editions acted as it is expected to act, the result would be to multiply the mischievous books.

Q. (*Mr. Trollope*). Do you not think that, in making the parallel that you have there made, you have failed to consider the mental capacities of readers?

A. I was about, in answering the next question, to deal indirectly with that; pointing out that while there is a certain determining of the quality of reading by the mental capacity, there is a certain range within which you may minister more or you may minister less. There are people who, if they are tempted, will spend all their time on light literature, and if they are less tempted will devote some of their time to grave literature. Already the graver books, the instructive books, those that really need circulating, are impeded very much by this enormous solicitation from the multitude of books of a gossipy, sensational kind. People have but a certain amount of time and a certain amount of money to spend upon books. Hence what is taken of time and money for uninstructive books is time and money taken away from the instructive; and I contend that, if there were a diminution in the quantity of the books of this sensational kind published, there would be a larger reading of the really instructive books; and that, conversely, the multiplication of this class of lighter books would tend to diminish the reading of instructive books. I am now speaking, not, of course, of the higher amusing books, because there are many that are works of value, but of the lower novels, Miss Braddon's and others such.

Q. Do you think that a man coming home, say, from his eight or ten hours' labor in court day after day is in a condition to read Lyell's "Geology" as men read one of Miss Braddon's novels?

A. We are speaking of some ordinary man. No, not an ordinary man, certainly.

Q. Have we not to deal with literature for ordinary men?

A. For both ordinary and extraordinary men; the whole public.

Q. Are not the ordinary men very much the more numerous?

A. Certainly.

Q. Is it not, therefore, necessary to provide some kind of literature, as good as you can, but such that the ordinary mind can receive and can turn into some profit, together with the normal work of life?

A. I am not calling into question in the least the desirableness of a large supply of literature of an enlivening and amusing and pleasant kind, as well as a large supply of graver literature. My remarks point to the literature that is neither instructive nor æsthetic in the higher sense, but which is bad in art, bad in tone, worthless in matter. There is a large quantity of that literature, and that literature I take to be the one which will be most fostered by the proposed measures. I do not in the least reprobate the reading of lighter works if they are good in quality. I refer to the class of works which I regard as not good in quality.

Q. But do not you think you must leave that to settle itself on those principles of free trade which you have just enunciated so clearly?

A. Certainly; I am objecting to a policy which would tend to encourage the one and not encourage the other.

Q. (*Sir H. Holland*). The subscribers to the London Library are, as you say, the *élite* of readers?

A. Yes.

Q. And is not that the reason why there is this difference as to the reading of good and bad books taken out from that library; is it not attributable to the fact that these people have probably bought and have in their own houses the good books, but that they want to look through these other books, and therefore get them from the library?

A. There may be a qualification of that kind; but inasmuch as a very large proportion of the readers of the London Library are ladies, and those who come for lighter literature, I do not think it at all probable that they would have bought Lecky or Maine, or any books of that kind.

Q. I ask the question because I rather think that you will find a very curious difference from that which you have been stating if you go to the Manchester and Liverpool free libraries. You will find there that the workingmen take out largely Macaulay's "History of England" and that class of books.

A. Well, whatever qualifications may be made in this estimate, or the inferences from this estimate, I do not think they can touch the general proposition that books of this kind which in the London Library circulate most largely, are books of the kind which circulate most largely among the general public, and books of the kind which a publisher of rival editions would choose. That is my point.

Q. But might not that very evil to which you refer be met by im-

proving the taste of the majority of the poorer readers, by enabling them to get at once cheap editions of good books?

A. The question is, which are the cheap editions that will be issued. I contend that they are the cheap editions of these books of a dissipating kind; and that the main effect will be to increase the dissipation.

Q. You do not think that the earlier publication of a cheap edition would raise the tone of readers?

A. I do not see that it would do so, unless it could be shown that that would tell upon the graver and more instructive books. My next answer, I think, will be an answer to that.

Q. If you improve the tone of the readers, of course it does tell upon the graver books for those who have time to read the graver books; but there is a large class of readers who have not that time?

A. Yes.

Q. (*Chairman*). Referring to the illustrations which you have just given of works which you would denominate as worthless, or comparatively valueless, did I hear among them historical memoirs and journals?

A. Crabb Robinson's "Diary," for instance; I call that a book of gossip, which anybody may read and be none the better for it.

Q. The question I should like to ask is, are you not of opinion that books of that sort are extremely valuable to the intending historian of the epoch to which they refer?

A. It may be that there are in them materials for him. I have not read the "Greville Memoirs" myself, and I have no intention of reading it; but my impression is that the great mass of it is an appeal to the love of gossip and scandal, and that it is a book which, if not read at all, would leave persons just as well off or better.

Q. Take Lord Hervey's "Memoirs," in the reign of George II.; if you had the privilege of reading that book you would probably say it was an extremely sensational book, but, knowing the position which Lord Hervey occupied in the court and family of George II., I presume we may take for granted that the extraordinary facts which he relates are facts; and if so they would form the basis of a great deal of truthful history, which would be written of that reign: would not that be so?

A. It might be so, no doubt.

Q. Then we understand you to mean that in your opinion the royalty system would not cheapen works that you would describe as valuable?

A. I think, on the average of cases, quite the contrary. I believe the system would raise the prices of the graver books. Ask what a publisher will say to himself when about to publish a book of that kind, of which he forms a good opinion: "I have had a high estimate given of this book. The man is a man to be trusted; the book possibly will be a success. Still my experiences of grave books generally are such that I know the chances are rather against its succeeding. If it should

be a success, and if I had ten years now to sell the edition, I might print one thousand; but, under this arrangement, a grave book not selling one thousand in three years, or anything like it, it will never do for me to print one thousand. Should it be much talked about by the end of three years, there might be a rival edition, and my stock would be left on my hands. Hence, now that there is this very short time in which I can sell the book, I must print a smaller number—say five hundred. But if I print five hundred, and expect to get back outlay and a profit on that small number, I must charge more than I should do if I printed one thousand and had time to sell them. Therefore the price must be raised." In the case of a book which did turn out a success, it might eventually happen that there would be a cheap edition issued, and that that raised price would not be permanent; but this argument of the publisher with himself would lead him to raise the price, not only of that book, but of the other grave books which he published, all of which would stand in the same position of possibly being successes, but not probably; and of these, the great mass, the nine out of ten that did not succeed, the price would remain higher—would never be lowered. There would not only be that reason for raising the price: there would be a further one. If a man in the wholesale book-trade, who puts down his name for a certain number of copies, knows that a cheaper edition will possibly come out by and by, the result will be that he will take a smaller number of copies than he would otherwise do. At the beginning he may take his twenty-five or thirteen, as the case may be; but as the end of the three years is approaching he will say: "No, I will not take a large number; I must take two or three." Then, still further, the reader himself will be under the same bias. He will say: "Well, this book is one I ought to have: I hear it highly spoken of, but it is probable that there will be by and by a cheap edition; I will wait till the end of the three years." That is to say, both wholesale dealers and readers would earlier stop their purchases, thinking there might be a cheap edition; and that would further tend to diminish the number printed and to raise the price.

Q. (*Sir H. Holland*). Might it not be that the publisher, instead of entering into those calculations that you have pointed out, would consider, knowing that other editions may appear: "What is the cheapest form in which I can print this book? What can I afford to give the author consistently with bringing out the cheapest possible book, so that I may be secure against any other publisher bringing out a cheaper edition?"

A. It would be a very reasonable argument, if he knew which, out of these various books of the graver kind, was going to succeed; but since nine out of ten do not succeed—do not succeed, at least, to the extent of getting to a second edition—do not succeed, therefore, so far as to make it at all likely that there would be a rival edition, and that a cheap edition would pay, he will never argue so; inasmuch as he

would in that case be printing, of the nine books that would not succeed sufficiently, a larger edition than he would ever sell. He must begin in all these cases of doubtful grave books by printing small editions.

Q. Where an author brings a book to a publisher, the first question the publisher asks himself is, of course, this: "Is this book likely to take?" and then, if he thinks it will take, he has to consider further, in what degree will it take? Will it have a large sale or limited sale? Because, in each case the book may be a success, though in a different degree. Then, if it is competent for any other publisher to publish an edition, it may be assumed that such edition would be a cheap one; and, therefore, has not the original publisher this further question to put to himself: "The book, I think, will take; but, looking to the chances of a cheaper edition, I must see what compensation I can give to the author, publishing this book as cheaply as possible, so that I may not be underbid hereafter"?

A. But I think that the experiences of publishers show that it does not answer their purpose to run the risk of cheap editions with the great mass of graver books; inasmuch as nine out of ten of them do not pay their expenses—and do not pay their expenses, not because of the high price, but because they do not get into vogue at all. The publisher would argue, "It will never do to print cheap editions of all these ten, because one out of the number will succeed."

Q. Of course he does not do so now, because there is not any possibility of another publisher underbidding him by a cheap edition; but I am assuming a case where any publisher, on payment of a royalty, can publish a cheap edition; then the original publisher would have to consider, "How cheaply can I publish this edition so that I may not be underbid by another publisher?"

A. That, I say, would altogether depend upon the experience of the publishers as to what was, in the average of cases, the sale of a new book. In most instances the sale of a new grave book is very small—not sufficient to pay the expenses; and I think the publisher would make a great mistake if, in the case of such a book, he counted upon getting a large sale at once by a low price. The other argument would, it seems to me, be the one he would use. In fact, I not only think so, but I find my publishers think so.

Q. (*Chairman*). Do you wish to instance any particular case in which you believe that a fixed royalty, such as we have heard about, would have hindered the diffusion of a book of permanent value?

A. Yes, I have an extremely striking, and, I think, wholly conclusive, instance of the fatal effects—the extensive fatal effects—that would have resulted had there been any such system existing as that proposed. I refer to the "International Scientific Series." I happen to know all about the initiation of that. It was set on foot by an American friend of mine, Professor Youmans, who came over here for the purpose. I

aided him, and know the difficulties that were to be contended with, and a good deal concerning the negotiations. The purpose was to have a series of books written by the best men of the time, in all the various sciences, which should treat of certain small divisions of the sciences that are in states of rapid growth—giving to the public, in popular form, the highest and latest results; and it was proposed, as a means of achieving this end, that there should be an international arrangement, which should secure to authors certain portions of profits coming from translations, as well as profits from originals at home, and the hope was that some publisher might be obtained who would remunerate these authors of the highest type at good rates, so as to induce them to contribute volumes to the series. Well, this attempt, after much trouble, succeeded. A number of the leading scientific men of England, France, and Germany, were induced to coöperate. A publisher was found, or rather publishers here and elsewhere, to enter into the desired arrangements; and an English publisher was found who offered such terms to authors in England as led men in the first rank (and I may mention Professor Huxley, and Professor Tyndall, and Professor Bain, and Professor Balfour Stewart, and a great number of others) to promise to write volumes. These men, I know, were reluctant, as busy men, with their many avocations, and their incomes to get for their families, would naturally be, and were induced to enter into the scheme only on its being made manifest to them that they would reap good profits. The English publisher offered a twenty per cent. commission on the retail price, paid down on first publication, and for every subsequent edition paid six months after date; and there were certain smaller percentages to come from abroad. Now, the English publisher proposed to give those terms, knowing that it would be impossible for him to get back his outlay unless he had a number of years in which to do it. He had to stereotype, he had to pay at once these sums to authors, and he had to publish the books at a cheap rate; for, by the way, I ought to have said that part of the plan was that these books should be sold at low prices: I may instance a volume of four hundred and twenty pages for five shillings. These terms would, I take it, have been absolutely out of the question had there been such an arrangement as that under which the publisher, instead of having many years to recoup himself, would have had rival editions to compete with in the space of three years. I do not, however, put that as an opinion. I have taken the precaution to obtain from Mr. King, the publisher, a definite answer on this point. This is the paragraph of his letter which is specially relevant: "Authors can have no difficulty in proving that this" (meaning the system which I told him was proposed) "would be most unjust to them, a confiscation, in fact, of their property; but I, from a publisher's point of view, should like to declare that the terms on which my firm have undertaken the 'International Scientific Series' would be impossible on such a limitation." Now here, then, we have a series of highly valuable books, I

think of the kind specially to be encouraged, amounting to between twenty and thirty already published, and potentially to a much larger number, which would not have existed at all had there been in force the arrangement proposed; inasmuch as the publisher affirms that he would not have offered such terms, and I can testify that, in the absence of terms as tempting as those, authors would not have agreed to coöperate.

Q. (*Sir H. Holland*). Was Mr. King made aware that there would be a limited time within which each volume would be protected?

A. Yes, three years. He did not count upon anything like adequate return in that time. He says, "We are a long way off profit as yet on the series" (I think it is nearly five years since it commenced), "although I am convinced that ultimately we and the authors, too, will be well satisfied."

Q. That would raise the question which I wanted to put, whether in a case like that it would have been possible to publish a cheaper edition than the one now published?

A. Yes, in the absence of the author's twenty per cent.

Q. In the case which you have brought to our notice, may we assume that the cheapest form of edition was published consistently with fair profit to the author and publisher?

A. I think, certainly, with anything like a tolerable mode of getting up. Of course, you may bring down a thing to rubbishing type and straw paper; but I was speaking of a presentable book. They are very cheap for presentable books.

Q. That, perhaps, would be one of the evils arising from a system of royalty, that you would get extremely bad and incorrect editions published of a book, even in the first instance?

A. Very likely.

Q. Because it would be the publisher's object, if that system were thoroughly established, to publish such an edition that another publisher could not underbid him at the end of the three years; that would be, would it not, the general object of the publisher?

A. Yes.

Q. In this case I understand you to say that he could not, consistently with fair profits to the author and publisher, and consistently with its being a properly printed work, without which a work of that kind would be of very little value, have published a cheaper edition?

A. He could not.

Q. And yet he would not have been able to publish such an edition if he had to run the risk of being underbid?

A. Certainly not. He says, "I confess my idea, in proposing such terms as those of the 'International Scientific Series,' looked forward to a yearly increasing interest in scientific literature, and an ever-enlarging circle of readers able to appreciate books of a high class." So he was looking for a distant effect.

Q. I am anxious, as Mr. King is not here, to get your own opinion upon that point: do you concur in his views?

A. Yes, certainly.

Q. (*Chairman*). Have you any further reasons for thinking that measures of the kind which we have been discussing, taken in the interest of cheapening books, might end in doing the reverse?

A. I think there is another way in which there would be a general operation of this system of rival editions, which would have, indirectly, the effect of raising the prices all round; namely, the waste of stock. It would inevitably happen that every publisher of an original edition would, from time to time, have a rival edition make its appearance before his edition was sold. In that case his remnant of an edition, gotten up in a relatively expensive style, would either have to be not sold at all or sold at a sacrifice. Further, it would happen from time to time that two publishers, unknown to one another, would issue rival editions, both of which would not be demanded; there would therefore be a waste of stock. Evidently the system of competing with one another in the dark would continually lead to production in excess of demand. What would be the result? If there is an increased percentage of waste stock, that has somehow to be paid for, if business is to be carried on at all. And as we know that tradesmen have to raise their average prices to cover their bad debts, so, if publishers find an increase of bad stock, they must raise their prices to cover the loss on bad stock.

Q. (*Mr. Trollope*). Would not the ordinary laws of trade correct such an evil?

A. This interference with the laws of trade would entail an abnormal production of waste stock. Under the present system a publisher does not publish a cheap edition till the other is gone; but under the proposed system, with cheap copies perhaps sent from the colonies, there must be waste stock.

Q. When the system had been in operation for a time, do you not consider that that evil would correct itself by the ordinary laws of trade? We are aware that at first the disruption of an existing state of things will create much confusion, and such evil as you have described; but are you not of opinion that this would rectify itself after a time?

A. I do not see how it could rectify itself, if the system of rival editions continued, and operated in the way that it is expected to do. But as I have already indicated by certain hypothetical remarks, I do not think it would continue and operate in that way. I say, however, that if rival editions were issued by men not knowing each other's doings, there must from time to time occur in the business of each publisher loss of stock.

Q. (*Chairman*). From the answer to the last question that has been put by Mr. Trollope, I gather it to be your opinion that the ar-

rangement would be practically inoperative, so far as the anticipated competition was concerned?

A. I think that, after a period of perturbation, a period of fighting and general disaster in the publishing business, there would arise a tacit understanding among publishing houses, which would, in a large degree, defeat the purpose of the measure; and I say this on the strength of definite facts furnished by trade-practices in America. These facts I have from the before-named American friend, Professor Youmans, with whom from time to time, when over here, I have had to discuss the probability of pirated editions of my own books in America. My books in America are published by a large house there, the Appletons; and they deal with me very fairly—pay me as well as any American authors are paid. I have gathered from Professor Youmans that the danger of the issue of rival editions of my books in America is very small; because there exists among the American publishing houses the understanding that, when one house brings out an English book, other houses will not interfere: the mere circumstance of having been the first to seize upon a book is held to give a priority, such as is tacitly regarded as a monopoly. That condition of things has been established through a process of fighting; for when it did at first happen that American houses brought out rival editions of the same English book, or one edition, rather, after another, that, of course, was a declaration of war between the two houses, and immediately there was retaliation, and it ended in a fight. The house attacked revenged itself by issuing, perhaps, a still cheaper edition, or by doing the like thing with some work subsequently published by the aggressing house; and after bleeding one another in this way for a length of time there resulted a treaty of peace, and a gradual establishment of this understanding, that they would respect each other's priorities. If that is what happened in America, when the only claim that a publisher had to the exclusive publication of a book was the claim established by prior seizing of it, and prior printing, much more will it happen here in England, among publishers who have paid for their books, or who have entered into arrangements with authors for half profits, or what not. Having established certain equitable claims to these books, they will very much more decidedly fight any houses that interfere with them, by issuing rival editions. If the men who have ill-founded claims fight, still more will the men who have well-founded claims fight. Hence there would occur among the English publishers, when this system came into operation, a period of warfare lasting, probably, for some years, and ending in a peace based on the understanding that any publisher who had brought out a book would be regarded as having an exclusive claim to it, and would not be interfered with. The fear of retaliation would prevent the issue of the rival editions.

Q. (*Sir Henry Holland*). And therefore would prevent the publication by a rival publisher of a cheaper edition?

A. Yes.

Q. (*Chairman*). Then on the grounds that you have explained, you think the system would become before long wholly inoperative?

A. Not wholly inoperative, I think: inoperative for good, not inoperative for evil. In the course of this early phase to be passed through, in which houses issued rival editions against each other and got into this state of warfare, it would happen that the weaker would go to the wall: the smaller publishers would not be able to stand in the fight with the larger publishers, and they would tend to fail. And further, although treaties of peace would be eventually reached between the more powerful publishers, who would be afraid of each other, and dare not issue rival editions of each other's books, there would be no such feeling on the part of large publishers toward small publishers. If a small publisher happened to issue a successful book, a larger publisher would have no fear in issuing a rival edition of that. Hence, therefore, the tendency would be for the small publishers to be ruined from having their successful books taken away from them. But that would not be the only tendency: there would be a secondary tendency working the same way. For, after this fighting had gone on a year or two, it would become notorious among authors that if they published their books with small publishers they would be in danger of rival editions, in case of success, being issued by large publishers; but that, contrariwise, if they published with large publishers they would be in no danger of rival editions. Hence they would desert the small publishers; and in a double way the small publishers would lose their business. We should progress toward a monopoly of a few large houses; and the power which such have already of dictating terms to authors would become still greater.

Q. And if I understand you rightly, the power would be not only to dictate terms to authors, but of price to the public?

A. Yes, they would be able to combine. When you got a small number of publishers, and they could agree to a system of terms, the public would be powerless against them, and authors would be powerless against them.

Q. Then, in your opinion, is there any way by which works could be cheapened by legislative enactment?

A. There is one way, and that a way in principle exactly the reverse of that which is contended for in this measure; namely, the extension of copyright. I do not mean the extension in time; I mean the extension in area. On this point I am happy to say there appears to be agreement between the two sides. From the evidence which I have read I gather that it is proposed along with this limitation of copyright in time to extend copyright in area. I do not altogether understand the theory which, while it ignores an author's equitable claim to the product of his brain-work in respect of duration, insists upon the equity of his claim to that product of his brain-work, as extending not only to

his own nation but to other nations. However, I am glad to have agreement so far; and I hold, along with those who support the proposed measure, that the enlargement of the markets by means of international copyright would be a very effectual means of cheapening books. It would be a more effectual means of cheapening books than at first appears, and especially a means of cheapening the best books. I may refer again to this "International Scientific Series." One of the means by which that series has been made cheap was, that the American publisher and the English publisher agreed to share between them the cost of production, in so far as that the American publisher had duplicate stereotype plates and paid half the cost of setting up the type. Now it is clear that if the outlay is diminished by having one cost of composition for two countries instead of a cost for each, the book can be issued at a lower rate in both countries than it could otherwise be. And that arrangement, voluntarily made, under a kind of spontaneous copyright, in the case of the "International Scientific Series," would be forced, as it were, upon publishers in the case of an established copyright. Consequently there would be habitually an economization of the cost of production, by dividing it between the two countries; and hence there would be a lowering of the price. And then there is the further fact that this would tell especially upon the more serious books. On books of a particular kind the chief cost is for paper and print—large editions being printed. Therefore it does not so much matter in America having to set up the type afresh. But in the case of a grave book of which the circulation is small, the cost of composition is the main element in the cost; and the economization of that cost, by dividing it between England and America, would serve very considerably to lower the price.

Q. (*Dr. Smith*). Then, if I understand you aright, you do not approve of the principle adopted in the Canada Act, in the act passed by the Canadian Legislature of 1875, confirmed by the Imperial Act, by which it is necessary in order to obtain copyright in Canada that the works should be set up afresh?

A. I think that is obviously nothing else than a means of staving off the opposition of printers, and a very mischievous arrangement.

Q. Would it not be the fact that if a work could be set up once for all in one country, and circulate in the two countries, the price of the book would be diminished?

A. Unquestionably.

Q. (*Sir H. Holland*). You are aware of the difficulties that have been raised by the United States publishers: that constant attempts have been made ever since 1854 and before to make a copyright convention, and that there is no very great probability of these attempts proving successful. Have you any particular suggestion to bring before the commissioners which would in your opinion tend toward making the Americans favorable to a convention?

A. I am sorry to say I do not see my way toward any such suggestion. I was merely replying to the general question whether legislation could do anything to cheapen books, and saying that the only thing I thought it could do would be to get, in some way, an extension of area for copyright.

THE FORMATION OF MOUNTAINS.

PROFESSOR ALPHONSE FAVRE, of Geneva, has been making an interesting series of experiments to illustrate the formation of the great inequalities of the earth's surface by means of lateral thrust or crushing. These he describes and illustrates in a recent number of "La Nature," to which we are indebted for the illustrations which accompany this article. Professor Favre refers to the early experiments of Sir James Hall with various kinds of cloth, which he made to assume a variety of shapes by means of weights. He speaks of the various theories of the elevation of mountains, and especially of that of H. B. de Saussure, whose term *refoulement* seems to have meant much the same as that used by M. Favre, *écrasement lateral.*

"The three systems," M. Favre says, "which account for the origin of mountains by forces which push the great mineral masses from below upward, from above downward, or laterally, do not differ so much from each other as at first sight appears. Those geologists who have admitted the system of elevations as the principal cause of modification of the surface of the globe would probably enough admit the formation of depressions as a secondary modification; and so those who have accounted for these modifications mainly by depression, would probably enough also admit elevation as a secondary factor. Again, in the system of lateral crushing, there is a general depression of the surface of the earth, since there is a diminution in the length of the radius of our globe, and yet there result elevations of the ground in the midst of this general depression.

"The cause of lateral crushing," M. Favre goes on to say, "is owing to the cooling of the earth. It is, in fact, very probable that our globe is at the stage when, according to Élie de Beaumont, 'the mean annual cooling of the mass exceeds that of the surface, and exceeds it more and more.' It must follow that the external strata of the globe, tending always to rest on the internal parts, are wrinkled, folded, dislocated, depressed at certain points, and elevated at others.

"The experiments," M. Favre continues, "which I have made at the works of the Geneva Society for the manufacture of physical instruments, resemble much those of Sir James Hall; they differ notably, however, in two points: 1. The celebrated Scotchman caused the matter

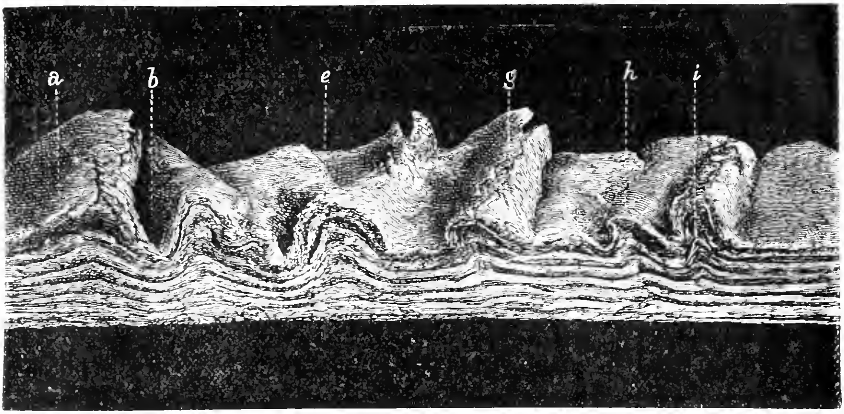


FIG. 1.

which he wished to compress to rest on a body which itself could not be compressed, while I placed the layer of clay employed in these experiments on a sheet of caoutchouc, tightly stretched, to which I made it adhere as much as possible; then I allowed the caoutchouc to resume its original dimensions. By its contraction the caoutchouc would act equally on all points of the lower part of the clay, and more or less on all the mass in the direction of the lateral thrust. 2. Hall compressed, by a weight, the upper surface of the body which he wished to wrinkle, which prevented any deformation, while by leaving that surface free, I have seen, during the experiment, forms appear similar to those of hills and mountains which may be observed in various countries. . . .

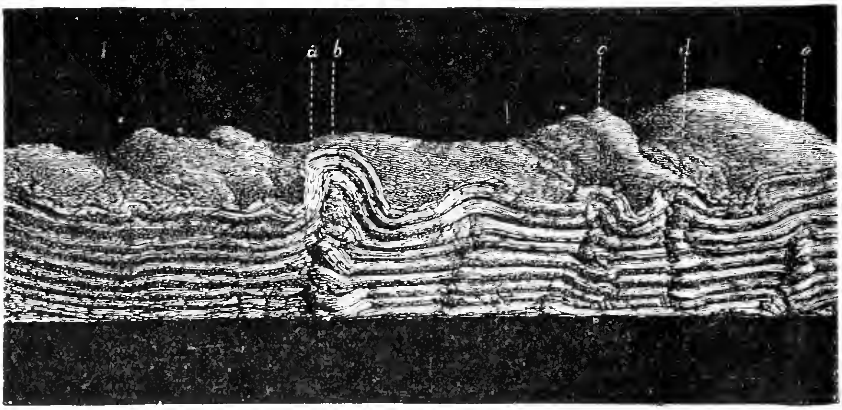


FIG. 2.

"The arrangement of the apparatus is very simple. A sheet of India rubber 16 mm. in thickness, 12 cm. broad, and 40 cm. long, was stretched, in most of the experiments, to a length of 60 cm. This was

covered with a layer of potter's clay in a pasty condition, the thickness of which varied, according to the experiments, from 25 to 60 mm. It will be seen from the dimensions indicated that pressure would diminish the length of the band of clay by one third. This pressure has been exerted on certain mountains of Savoy. For example, the section which I have given [1] of the mountains situated between the Pointe-Percée and the neighborhood of Bonneville enables it to be seen that those folded and contorted strata which are shown between Dessy and the Col du Grand Bernard cover a length which is two thirds of that which they had before compression. These mountains, then, have been subjected, like the potter's clay, to a compression indicated by the ratio of 60 to 40. Contortions are not, perhaps, observed over all the surface of the globe; it has not been equally folded in all its extent, but they are found in a great number of countries, and even beneath strata almost horizontal. Sometimes the folds approach the vertical, and are close against each other; this structure indicates that pressure has been exercised in a stronger manner than I have indicated.

"These powerful lateral thrusts of the external and solid parts of the globe appear to result from a diminution which the radius of the interior pasty or fluid nucleus has undergone during millions of ages. It may have been sufficiently great to cause the solid crust (which must always have been supported on the interior nucleus, whose volume continually diminishes) to assume the forms which we know, with a slowness equal to that of the contraction of the radius.

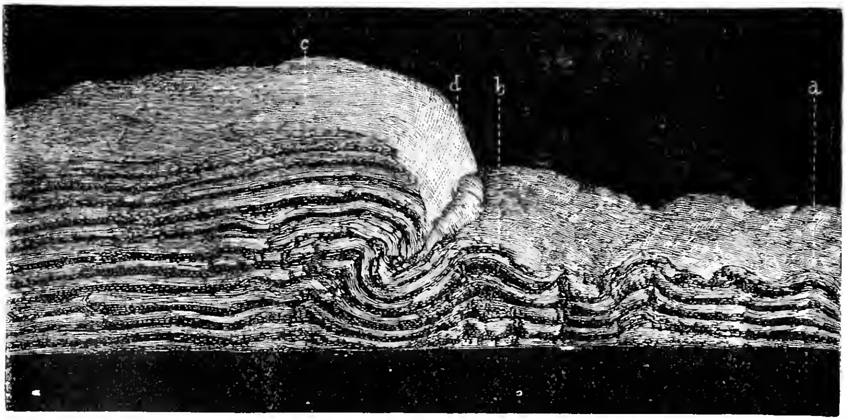


FIG. 3.

"To return to my experiments. At the extremities of the band of clay are pieces of wood or supports, which accompany it in its movement of contraction. The clay is thus compressed at once by its adhesion to the caoutchouc and by lateral pressure of the supports. By

[1] "Bulletin Société Géologique de France," 1875, t. iii., pl. xxii. A. Favre, "Recherches Géologiques," Atlas, pl. ix.

the influence of the caoutchouc alone, without the presence of the supports, there are formed only slight wrinkles on the surface of a sheet of clay 3 or 4 cm. in thickness; and if the supports alone compressed the clay placed on a material which is not compressed (a very smooth oiled plate), the clay scarcely wrinkles near the center of its surface; it increases a little in thickness and forms swellings (*bourrelets*) against the supports. The strata which appear to divide the masses of clay, and which are represented in the figures, are not really strata, but simply horizontal lines at the surface of the clay."

Such pressure as has been applied in these experiments produces contortions of strata which elevate the surface of the matter compressed, as well in the plane parts or plains, as in those which take the forms of valleys, hills, or mountains. These latter have the appearance of vaults or folds, sometimes perpendicular, sometimes warped (*déjetés*); the ridges are complete, or broken at the summit by a longitudinal fracture, narrow below and wide above; next, another fracture, narrow above and wide below, is produced at the base of the mountain or vault. The sides of valleys are sometimes almost vertical, sometimes present gentle slopes. The strata are less strongly contorted in the lower parts than in the neighborhood of the upper surface. They are disjoined in certain parts by fissures or caverns; they are traversed by clefts or faults inclined or vertical. All these defor-

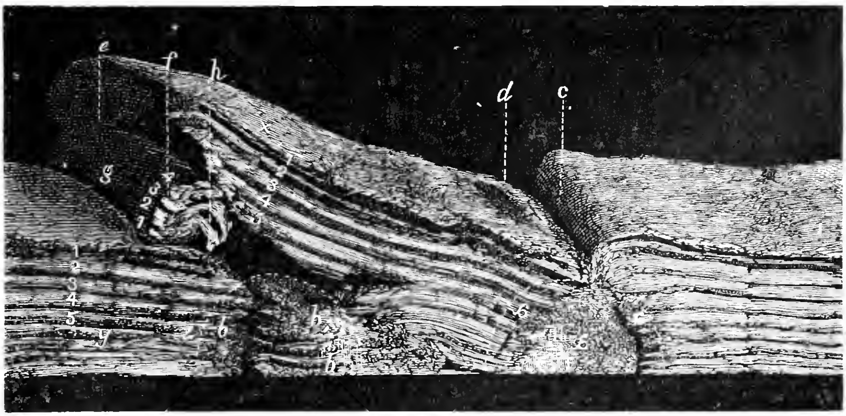


Fig. 4.

mations are the more varied in that they are not similar on the opposite sides of the same band of clay.

Most of these phenomena are seen in Fig. 1, which represents the result of an experiment made on a band of clay whose thickness before compression was about 25 mm., while after that it attained 62 mm. at the culminating point. At *a* is seen a vault a little broken at the summit, covering a cavern similar to that figured in the memoir of Sir J. Hall

("Transactions R. S. E.," vol. vii., 1813), and to that of the Petit Bernard in Savoy (Favre, "Recherches," pl. x.); at *b* is a valley open at one of its ends and almost closed at the other; at *e* is a vault almost straight, the prolongation of which is very level; at *g*, *h*, and *l* are vaults twisted and a little broken, while at *i* is a broken fold, the curves of which are almost vertical. All these accidents of the ground recall those which have been so often observed in the Jura, the Alps, and the Appalachians.

Fig. 2 represents a band of clay whose thickness was about 40 mm. before compression and 65 after. We remark contortions similar to those of the preceding figure, among others a vault *a*, very exactly formed. At distances are seen vertical slices, on which the pressure appears to have acted in a particularly energetic fashion, and which may be called "zones de refoulement"; the strata are there broken in an exceptional manner, often separated from each other. One of these vaults is replaced by a single vault on the opposite side of the band of clay.

Before compression, in the band of clay in Fig. 3, were seen the two divisions which are seen there now—that in the right was 33 cm. long and 25 mm. thick at *a*, and 35 at *b*; the left division was 25 cm. long and 65 mm. thick. A gentle slope united the part *c* to the part *b*. After compression, the mean height of *a b* was 45 and that of *c* 75 mm. All the layers were spread horizontally.

"In this experiment I have sought to imitate the effect of crushing at the limit of a mountain and a plain. The height of the mountain *c* has been notably increased, the five or six upper layers have advanced on the side of the plain; they encroach on it. The plain has, however, offered a resistance sufficiently great to cause the strata of the mountain to be strongly inflected at the bottom. From this struggle between the plain and the mountain there resulted a cushion, *d*, which is the first hill at the foot of the height. It also resulted that the strata of the plain assumed an appearance of depression at contact with the mountain in consequence of the vault which is formed at *b*; they plunge underneath the mountain. This resembles what is often seen in the Alps at the junction of the first calcareous chain and the hills of 'mollasse'; in fact, the strata of the latter rock seem to plunge under those of the neighboring heights. In consequence of the pressure, there are formed several ranges of hills in the plain between *b* and *a*.

"In Fig. 4 the band of clay had, before compression, a thickness of 45 mm.; after that the culminating point was more than 10 cm. I have here sought to represent what must happen when terrestrial pressure is exerted on horizontal strata still moist, deposited at the bottom of a sea where are two mountains already solidified. For this purpose I placed in the caoutchouc and under the clay two bare cylinders of wood, *a* and *b*, of about 35 mm. radius, at 20 cm. from the ends of the

band of clay, and at the same distance from each other. Before compression the surface of the clay and the strata were completely horizontal. Pressure gave rise at the top of the half-cylinder, *a*, to a valley, *c*, formed by a twisting of the beds to the right, and by a little mountain, *d*, to the left. But I do not believe that it has ever been thought to assign to a valley an origin of this nature.

"On the other semi-cylinder, *b*, is produced an enormous elevation which has carried the ground to *e*, with such a rupture that the left lip, *f*, *g*, has suffered a complete reversal by turning, as on a hinge, around the horizontal line which passes by the point *h*. It follows that the four upper strata of clay designated by the figures 1, 2, 3, 4, being in a normal position before compression, are, after that, so arranged as to show the succession represented by the following arrangement of figures: 1, 2, 3, 4, 4, 3, 2, 1, 1, 2, 3, 4, making the section of this formation by a line drawn from *x* to *z*. If the left lip should disappear we should then have between the points *x* and *z* the section 1, 2, 3, 4, 5, 1, 2, 3, 4, 5. Sections analogous to these, presenting inversions in the order of strata, are known to geologists.

"The forms assumed by the clay depend on several circumstances which it is difficult to describe, such as the strength and the rate of compression, the thickness and the greater or less plasticity of the clay, etc. Why have accidents of the upper surface of the clay, which are intimately connected with those of the interior of the mass, so small an extension that they are not even similar in the two sides of a band of clay? This small continuity is owing to causes which we can neither foresee nor appreciate. Is it not the same in nature? Why is the chain of the Alps not a true chain, but a succession of masses often oblique with respect to each other? Why, in the Jura, do we see chains which have for their prolongation plains and valleys? It is always the case that the forms and structures obtained in these experiments have an incredible resemblance to those which are found on the surface of the globe. But it must be admitted that many of the latter have not been reproduced by these artificial crushings.

"It appears probable that, by pressures more powerful and more variedly employed, we might obtain again very different structures. But I have not thought it necessary to multiply these experiments, thinking that the varied forms which have resulted show sufficiently the effects of crushing."—*Nature.*

PLANETARY RINGS AND NEW STARS.

By Professor DANIEL VAUGHAN.

THE study of celestial phenomena which represent changes of the greatest magnitude is an important source of intelligence respecting the course of creation and the diversified condition of the universe. In all well-directed efforts to explore the more profound secrets of space and of time, it is necessary to be guided by certain conspicuous marks which even unseen planets may leave behind them, on assuming new forms or in closing an inconceivably long term of existence. Within the solar domain there is, perhaps, no object which claims more interest or value for original inquiries in astronomy than Saturn's rings—whether they be regarded as presenting a picture of the first or the last stages of planetary life. With a wide deviation from the ordinary figure of worlds, they exhibit changes which are interesting on account of the vast scale on which they occur, and the light which they throw on the past and the future history of the solar system. In the absence of those restraints which secure much repose on the surface of our globe, the Saturnian girdle is abandoned to rage of the most violent commotions and becomes occasionally the seat of disturbances which, though transpiring at the distance of about 900,000,000 miles, are yet revealed by the telescope. The temporary divisions which have been so often observed in the rings are evidences of the terrific scenes of turmoil in this remote theatre of chaotic activity; as the opening and closing of visible chasms must be attended with physical convulsions immeasurably greater than any ever witnessed on our terrestrial abode.

From well-established principles of physical astronomy, it is easy to prove the impossibility of tranquil movements in a region so close to the great planet. Whether tenanted by innumerable solid masses or even by a vast expanse of fluid, the zones in which the Saturnian sway is so powerful must present a long-continued struggle for opposite ends. The matter spread over the wide annular fields is ever urged by its own attraction to collect together and form satellites, which are soon destroyed by the attractive disturbance of the primary, and have their parts scattered once more over a wide space. From the gravity due to their preponderating masses, the mountains or inequalities observed on the ring can not be prevented from growing at the expense of the matter along the zone in which they circulate; but with the increasing size the vast structures become at last incapable of sustaining the crushing strain in certain directions; so that a dilapidation and a dispersion of their materials become inevitable. It is in consequence of the ephemeral character of these mountains or embryonic satellites, that observations on them have sometimes led as-

tronomers to absurd and discordant conclusions in regard to the general movements and the stability of the rings.

With the resources which spectrum analysis has conferred on science, more advantages are to be expected from inquiries in regard to the exact nature of the matter of distant space; and the basis for opinions or conclusions in regard to the composition of celestial objects is more then usually favorable in the case of Saturn's bright rings. That they are not entirely liquid or gaseous is evident from their serrated edges shown in the observations of Trouvelot, and from the peculiar character of the inequalities observed during their disappearance by Lassell and other astronomers. And yet there are few solid substances which could endure the long course of turmoil and ruin without being reduced to powder, and thus rendered incapable of raising mountainous structures high enough to be visible from our earth. But if the great annular appendage were largely or wholly composed of water with a temperature near 32° Fahr., the readiness of the fluid to assume a frozen condition would be a remedy to the ceaseless work of destruction, and would give solidity enough to enable incipient satellites to rise to the height of more than one hundred miles before tumbling to pieces.

The range of temperature necessary for the continuance of such operations must be maintained chiefly by the thermal effects with which they are attended. Any large stock of primitive heat which (according to the more generally received opinions) the rings might have possessed at their origin, must have been long since wasted by radiation from their extensive surfaces. In that remote and frigid zone of our planetary domain, the rays of our sun are too feeble to mitigate the rigors of extreme cold; and the outer ring at least can obtain but little calorific relief from the great planet which it environs. But, from the incessant changes and convulsions in the restless fields of matter, heat is abundantly produced by the violent mechanical action which, in a ring of aqueous composition, would proceed in a manner calculated to give a uniformity of temperature. If such a half-frozen ocean were abnormally heated throughout much of its vast expanse, so that a large portion of its ice were liquefied, the water, on obtaining a preponderance, would perform its movements and fluctuations with less violence and loss of living force. The heat produced mechanically would be then less than the amount lost by radiation, and a return of cold would again give ice the ascendancy. Yet, as the temperature declined and the freezing extended, mechanical violence would again become more energetic; and heat would be more copiously developed by the collisions of icy blocks, and by the rise and fall of gigantic mountains.

Reasoning from the most reliable principles of physics, and guided by the light of recent discoveries, many eminent scientists have come to the very just conclusion that the movement in Saturn's rings must be attended with a loss of energy and a reduction in the size of the orbits

described by the innumerable disconnected masses of which the curious appendage is now generally believed to be composed. The opening and closing of its chasms, and other observed signs of its restless character, are calculated to give the impression that the extent to which it is altered during many years must be considerable. But, considering the conditions necessary for the phenomena it exhibits, it would seem that the rapidity with which its changes proceed might be approximately determined from the amount of heat which it radiates into space, and which must have been, for the most part, produced at the expense of its motion. Now, though the rings may be principally composed of water, and have a superficial temperature near the freezing-point, yet, their surfaces being over a hundred times as extensive as that of the earth, they may be reasonably supposed to lose by radiation about thirty times as much heat as our planet receives from the sun and allows to escape into space. Taking Bessel's estimate for the mass of the double girdle, it will be found that such an amount of heat might be generated by the conflicting movements of its parts without reducing their orbits more than one per cent. in ten thousand years. There is, indeed, reason to believe that, in this case, Bessel's results are unreliable, in consequence of the uncertain and defective character of the data with which they were obtained. If we assign to each ring the probable amount of matter in the neighboring moons of the gigantic planet, it would seem that their permanent change of size may be so considerable that it might be detected by the observations of a few centuries.

It is likely that, in the inner ring, especially at the zone nearest to the primary, the temperature is much higher than that which I have supposed, and that alterations in its condition might proceed at a rate sufficiently rapid to be discoverable by the telescope. More than twenty years ago Otto Struve, having carefully compared observations since the time of Huygens, announced as the result of his labors that the inner ring is changing its dimensions so rapidly that before two hundred years it will be united to the planet. Other astronomers have expressed a belief of the recent origin and of the mutable nature of the obscure or vapor ring which lies closer to Saturn. The conclusions of Struve, however, have been disputed; and indeed it is probable that they give an exaggerated picture of the transitory state of things in the Saturnian dominions; nor can the conflict of opinions on this point be settled by observation alone. But, though taking place too slowly to be at once detected in this way, the changes in question are still inevitable; and they give safe ground for tracing the history of past events in this part of the celestial regions. It is evident that the matter composing Saturn's wonderful appendage must have once moved in a wider zone, where it could exist only in the form of two secondary planets. I have shown in a previous article that a dismemberment and a conversion into a ring must be the general fate of every planetary body which, by a slow contraction of its orbit, revolves at last too close

to its primary. From these and other considerations it may be legitimately concluded that the rings of Saturn are the remains of two former satellites; and their origin and their present condition must be regarded as the ultimate consequence of a rare medium disseminated through space.

Though the dismemberment which I have shown to be inevitable in small orbits differs, in some features, from that supposed to take place in the nebular hypothesis, yet in tracing the effects of both it is necessary to be guided by certain mathematically demonstrated principles in regard to stability. Two homogeneous fluid planets varying widely in size, but having the same density and occupying the same time in their diurnal movement, would be similar spheroids, or have the same relative deviation from a true sphere. Stability would cease to be possible in both if they were as dense as the earth and turned once in two hours and twenty-five minutes. If they were as rare as hydrogen gas at the level of our seas, they could not endure a rotation which took place in a less time than twenty-five days. In the investigations which I have given in the "Philosophical Magazine" in regard to secondary planets close to their primaries, the results have a like generality. Twelve hours would be very nearly the shortest time of revolution for an homogeneous fluid satellite as dense as water, whether its diameter were a hundred or a thousand miles, or whether it revolved around the earth or around Jupiter. Such a body, however, would require to be about thirteen times as dense as its primary in order to circulate in safety a little beyond the surface of the latter orb. A small satellite composed of fluid quicksilver would be capable of maintaining a planetary form if revolving just outside the atmosphere of Saturn or of Neptune; but it would be doomed to dismemberment if moving in a similar proximity to the surface of the earth or even of Jupiter.

The results are not very different even in cases of the greatest possible deviation from the homogeneous character I have ascribed to the bodies. If both planet and satellite were composed of rare gas enveloping a central nucleus, the smaller body would require to have an average density nearly eight times that of the greater, in order to preserve its integrity in such a dangerous proximity. A modern advocate of the nebular hypothesis supposes that each planet, when formed from the rarefied matter of a previous solar ring, was fifteen times less dense than the sun would be if it were an homogeneous sphere inclosed by the planetary orbit. In his own words, "After all their contraction during their condition as rings, and during their aggregation into globes, we may assume at a moderate estimate that when their rotation began they were fifteen times less dense than the average density of the sun expanded to their orbits." To change from a ring to a planet, however, the nebulous matter should have about one hundred times the density which the writer ascribes to it. Before it could become dense enough for the transformation, the nebulous expanse would, like

Saturn's rings, be a prey to great commotions, sustaining a constant loss of energy and contracting the circles which its parts described around the sun. In endeavoring to account for the direct motion in secondary systems, Laplace contends that, in consequence of friction, the supposed primitive solar rings would have a greater velocity in their outer than in their inner zones. Now, if friction were so potent as to counteract to such an extent the normal effects of gravitation, it must be an eternal bar against the origin of worlds by nebulous dismemberment; and if a ring of attenuated matter were placed under the circumstances suggested by the eminent astronomer, it would be ultimately doomed, not to form a planet, but to coalesce with the immense spheroid of fiery vapor which it is supposed to have environed.

For further progress in the task of tracing the course of celestial events and thus obtaining materials for an astronomical history of worlds, it is necessary to consider, not only the theory of motion and stability in comparatively small orbits, but also the effects which a resisting medium of space may produce during long periods of time. Though the evidence which cometary motion gives of this rare fluid is far from being satisfactory, more reliable information on the subject may be gleaned from other sources, as I pointed out in an article in the "Philosophical Magazine" for June, 1861. In the September number of "The Popular Science Monthly" I alluded to the form of Mars as bearing marks of a former rapid rotation which appears to have been considerably reduced by the friction of a space-pervading fluid. But by far the most acceptable evidence on this question has been lately derived from the peculiarities of the nearest moon of Mars, as the small size of its orbit and its brief period of revolution have been ascribed to a resisting medium, even by advocates of the nebular hypothesis. The bearing of the new discoveries on certain astronomical doctrines has been already pointed out, in the July number of this journal, by my long-esteemed friend whose useful life has been since lost to the cause of science. The effects of the space-pervading fluid will appear more decided if we regard the diminutive satellites as former asteroids which became so far a prey to the Martian attraction as to be reduced to their present subordinate condition. Such views respecting their origin were first suggested by Prof. Kirkwood, and were subsequently advocated by Prof. Alexander in a paper read before the National Academy of Science.

The possibility that some straggling fragments from the ruins of one world might become the satellites of another, depends on a principle which has been long applied in tracing the origin of the cometary members of the solar family. It has been maintained by Laplace that comets were at first strangers in our system, and that many of them, coming from remote interstellar regions and entering the sphere of the sun's attraction, obtained a permanent domicile in his extensive domain; their orbits being changed from hyperboles to ellipses chiefly by some planetary disturbances. There would, however, be less probability that

a small asteroid would become a satellite to Mars on passing through the region over which his attraction is effective ; as the change would depend mainly on the intervention of solar influence, and would require rare conditions which the movements of many hundred asteroids could furnish only during long periods of time. But it may be considered certain that a moon obtained in this way must have had its primitive path so very extensive, that its revolution occupied a term of several months. Accordingly, if the asteroidal origin of the Martian moons be adopted, their present condition must be indicative of greater deviations from their primitive arrangement ; and it is evident that their early large orbits could be reduced to the present small size only by a resisting medium. This theory is, perhaps, not wholly proof against all objections, but another which accounts better for the movements of both small secondaries in the plane of the equator of the planet, and which I intend to set forth in a future article, involves also the necessity of supposing the imperfect vacuity of celestial space.

As, in traversing a rare medium, such small masses must lose more velocity in one year than our globe would in many centuries under the same circumstances, they afford the most available means for indicating the slow alterations in the state of the universe. In the absence of the diversified cases which are, no doubt, concealed from our knowledge in distant solar systems, the small moons will serve as the means of illustration of the ultimate effects of the slight but constant resistance to celestial motion. It is evident that not many million years can elapse before Phobos will have its orbit so far reduced that it will sweep through the atmosphere of Mars, and then its career as a small secondary world will close with a meteoric exhibition. A term of existence several hundred times longer must be ascribed to our moon, or to the first satellite of Jupiter; but their end would be signalized by a far greater display of meteoric effulgence. A secondary planet two or three thousand miles in diameter, even if solid, would become unstable before coming in contact with its primary, and would undergo a sudden dilapidation ; so that a numberless host of its fragments, scattering into smaller orbits and plunging as meteors into the atmosphere of the great central orb, would send forth a flood of brilliancy sufficient to rival solar light, and to proclaim the great work of destruction to the most distant parts of the universe.

The paroxysmal manifestation of light which a planet could scarcely fail to call forth in thus passing through its final stages of existence, corresponds in every feature to the mysterious effulgence of temporary stars. The accordance of the theory with facts appears more satisfactory, in proportion as the problems involved in the inquiry are more accurately solved with the aids of mathematics, and as new means of observation reveal the true nature of these rare and transitory apparitions of stellar light in the skies. The theatre of one of the great meteoric exhibitions in question may be the aërial envelope, not only

of a large planet or a vast dark central body presiding over unseen planetary members, but even the corona and the photosphere of a sun. Whenever any of the large members of a solar or of a secondary system become unstable in too small an orbit, a vast portion of its dilapidated mass would be quickly sweeping as innumerable meteors through the atmosphere of the immense primary sphere. This accounts for the incipient brilliancy of the temporary stars, a fact hitherto unexplained, though it is generally admitted, and though it has been recognized by a high authority as a valuable guide in the study of these mysterious phenomena. "The circumstance," says Humboldt, "that nearly all the new stars burst forth at once with extreme brilliancy as stars of the first magnitude, and even with still stronger scintillations, and that they do not appear, at least to the naked eye, to increase gradually in brightness, is in my opinion a singular peculiarity, and one well deserving of consideration." Recent discoveries, though calling for some modification in this statement, detract little from its value; for the three new stars of the present century, though all below the first magnitude, yet showed their greatest effulgence at an early period of their visibility, and afterward exhibited a constant decline. According to the present theory, a rapid weakening of brilliancy in these objects would be an inevitable result: as a large portion of the meteors must have been successively precipitated to the surface of the great central sphere; while the balance assumed a closer array, changing their orbits into circles and forming a solar or a planetary ring.

The most favorable circumstances for such sudden outbursts of light are presented in cases where, in mass and size, the subordinate world is little more than one per cent. of the solar or the primary orb with which it is doomed to incorporate. If, for instance, our moon were caused to revolve so near us that it would be rendered unstable by terrestrial attraction, its dismemberment, though occurring on a large scale, would be confined to the region nearest to the earth. A vast portion of the lunar matter torn from this locality would be hurled to our globe or would fly as innumerable meteors through our atmosphere. But the remainder of our satellite would retire to a greater distance from the earth; and millions of centuries would elapse before it became again close enough to our world to suffer another great dilapidation and to give occasion for another gigantic display of meteoric light. It would thus appear that many great luminous exhibitions would attend the awful paroxysms with which a large planet passes away from the stage of existence in a solar or in a secondary system. Though a small satellite, if fluid, may meet its final doom in an obscure manner, yet, if solid, it would be likely to maintain a planetary form until it came very close to the primary; so that on its dilapidation a large portion of the resulting fragments would sweep through the atmosphere of the latter and call forth a sudden effulgence which in very remote worlds would appear as the transitory glare of a temporary star in the firmament.

In carefully tracing the conspicuous scenes which must mark the end of a planetary career, and thus obtaining a more correct interpretation of the rare and mysterious characters occasionally inscribed in our skies, very interesting information may be obtained of the diversified contents of space, and the long term of existence assigned to each of the numerous worlds of creation. If the dominions of other suns be equally rich as our solar region in mundane objects, it may not be extravagant to suppose that, in our universe, the large primary and secondary planets enlivened by the genial influence of more than twenty millions of stellar bodies might equal in number half the population of our globe. Now, the average mortality in the human family is about one death every second, while astronomical records show that only twenty-three temporary stars appeared within the past two thousand years. Taking their appearance as records of planetary fate, it would follow that a century is as small a part of the career of a planet as two seconds is of human life; and that the few thousand years in which the history of our race is comprised is scarcely two minutes in the immeasurable age of our world.

Yet these considerations will perhaps give an inadequate idea of the long endurance of the great works in creation's wide domain. According to the opinions of Laplace, besides the systems over which visible stars preside, there are others equally numerous in which the central bodies, though of sunlike magnitude, are not self-luminous. Mädler and Bessel embraced similar views. Those who believe, with Helmholtz, that a sun's heat and light are produced by the contraction of its mass, and that solar activity has a limited duration, might be naturally led to consider dark systems a hundred or even a thousand times as numerous as those which are illuminated. Yet I think it more reasonable to take the moderate estimate of Laplace for the comparative numbers of the dark and the bright occupants of space. But it is, moreover, necessary to consider that great planets and satellites meet their ultimate doom by a number of dismemberments and great meteoric scenes, each separated by intervals of many millions of centuries. Taking all these circumstances into account, the age of a world, as inferred from the observed indications of catastrophes in the heavens, may reach as high as 500,000,000,000 years.

If the feelings of some readers will revolt from the idea of having a primary or even a secondary mundane orb occasionally sacrificed in some part of the wide celestial domain, they must be powerfully shocked by the views of Dr. Croll, who gives destruction a far more oppressive sway over the great works of creation, when he regards the collisions of suns as the normal means of perpetuating the economy of nature. If the great centers of unfailing light were thus hurled into ruin, their attendant worlds, if saved from a worse fate, would be sent adrift in hyperbolic orbits and doomed to a long pilgrimage in the cold interstellar regions. Without denying the possibility of such rare and

terrific convulsions, I must pronounce it as certain that they can not have any part in giving birth to the new stars which astonished Tycho Brahe and Kepler, or to those which have blazed forth in the heavens in our own times. Though the greater cosmical bodies might, as Dr. Croll supposes, be heated by collisions so intensely as to be capable of diffusing heat and light for many millions of years, they could not undergo the rapid decline of brilliancy which temporary stars exhibit. Lockyer takes similar grounds in speaking of Nova-Cygni. "We are driven," says he, "from the idea that these phenomena are produced by the incandescence of large masses of matter, for, if so produced, the running down of brilliancy would be exceedingly slow." A planetary wreck, incorporating with the sun in the manner I have described, would sweep through his external matter at the rate of about two hundred and eighty miles a second. The heat produced mechanically at the expense of this high velocity would not be so great in quantity as that which might be expected from Dr. Croll's solar encounters; but, being confined to a very limited zone, it would attain much greater intensity, be more effective for dissociation, and prove a more efficient means for giving nebulæ their existence and the peculiar character which they exhibit.

Since spectrum analysis has been brought to bear on the new stars, the doctrine of their meteoric origin has obtained more currency in astronomical circles. Though the incorporation of a remote world with a greater sphere around which it previously revolved has been suggested as the cause of such meteoric action, the idea has been somewhat unproductive, in consequence of the loose manner in which inquiries on the subject have been conducted, and the little care which has been taken for obtaining correct solutions for the problems of motion and stability involved in the questions at issue. The consequences of instability and dismemberment in small orbits have been generally overlooked. Recent developments, however, show some steps for correcting the early errors and oversights in this new field of investigation. In his recent work on "The Struggle for Existence in the Heavens," Du Prel (alluding to the ultimate doom of the earth near the center of our system) states that our world will end its career, not as one gigantic meteor, but as numberless meteoric fragments; and then the great shower of stones in the solar atmosphere will show the inhabitants of some very remote orb such a spectacle as was to be seen by terrestrial astronomers in the constellation of Corona on the 12th of May, 1866. A similar conclusion has been expressed frequently in my writings during the past twenty-five years, especially in my papers published in the reports of the British Association for 1857 and 1861, and in my communications in the "Philosophical Magazine" for 1858, 1861, and 1872.

The meteoric phenomena of distant space may be profitably studied in connection with those to be seen on a diminutive scale in our at-

mosphere. The visits of shooting-stars to the earth have been lately brought within the province of astronomy, and numbers of these bright objects, which take part in extraordinary showers, have been found to come from the tracks of certain comets. It would, accordingly, seem that cometary bodies have portions of their matter separated from them, and occasionally sent as meteors into the atmospheres of the planets. The dismemberment which, in such cases, is occasioned by the heat, and more rarely by the attraction of the sun, is analogous to that which planets would suffer in very narrow orbits; but it occurs on a scale infinitely smaller, and can never be productive of any very conspicuous results. The greatest exhibition of shooting-stars in our atmosphere could never be observed from any of the neighboring planets; and, if armies of meteors were sent from many systems to invade a single one, and had their orbits and positions best arranged for a simultaneous charge on the atmosphere of one of its larger orbs, the light which they could produce would fail to exhibit the remarkable features observed in incipient brightness and the gradual decline of temporary stars.

THE OLD PHRENOLOGY AND THE NEW.

By Dr. ANDREW WILSON.

THERE has ever lain a strange fascination, for culture and ignorance alike, in the attempt to diagnose the intellect and character of man from the outward manifestations of his face and skull. The problem of character and its interpretation is as old as Plato, and may probably be shown to be more ancient still. Egyptian soothsayers and Babylonian astrologers were hardly likely to have omitted the indexing of character as a profitable and at the same time legitimate exercise of their art. The forecasting of future events and the casting of nativities were studies likely enough to bear a friendly relationship to the determination of character from face, from fingers, or from skull and brain itself. But the histories of palmistry and soothsaying, with that of physiognomy, are they not all writ in the encyclopædias? We shall not occupy space with an historical *résumé* of the efforts of philosophy in swaddling-clothes attempting to wrestle with the great problem of mind and matter; nor shall we at present venture to oppose a scientific denial to Shakespeare's dictum that

> . . . . there's no art
> To find the mind's construction in the face.

Darwin's "Expression of the Emotions," the development of facial contortions, and the interesting study of the genesis of smiles and tears, and of the thousand and one signs which make up the visible and emo-

tional life of humanity, may form a subject for treatment hereafter. Our present study concerns the deeper but not less interesting problem of the indexing of mind, and of the relations of brain-conformation and brain-structure to character and disposition. If there exists no art "to find the mind's construction in the face," Lavater notwithstanding, may we discover "the mind's construction in the skull"? If the old phrenology, or the science of brain-pans, be regarded as practically obsolete among physiologists and scientific men at large, what hopes of successfully estimating the "ccinage of the brain" may the new phrenology be said to hold out? To this interesting question, then, let us ask the reader's attention for a brief period. We may premise that, if the march in ways phrenological be somewhat bellicose, our journey shall not be wanting in those mental elements which make for instruction in a field largely peopled with human hopes and fears.

The professions of phrenology are not by any means so correctly appreciated as might be thought, considering how well known is the name of the science, and how popular were its tenets within, comparatively speaking, a few years back. Although the name "phrenology" is but an echo in the scientific class-rooms, its professors still flourish, mostly in obscure localities in large towns, and often present themselves as modern representatives of the Peripatetici, in that they wander from town to town as traveling philosophers who usually unite a little electro-biology to their phrenological talents, and throw in an occasional mesmeric *séance* by way of offset to the more serious business of the interpretation of character. There are, it is true, phrenological societies and museums in several of our cities. The latter are chiefly remarkable for the varied collection of murderers' effigies and for the extensive assortment of casts of cranial abnormalities; the exact relationship of these contorted images to phrenological science being rarely if ever made clear to the visitor on the search for knowledge. Now and then in opticians' windows one sees a wondrous china head whose cubic capacity is mapped off into square inches, half inches and quarters, of veneration, ideality, comparison, benevolence, and many other qualities of mind. The contemplation of such a work of art excites within the mind of the ingenuous observer an idea of the literal awfulness of a science which dispenses destructiveness by the inch, and which maps out the bounds of our amativeness by the rule of three; while the profundity of its professors may by such a mind be compared only to that of Butler's *savant* who

. . . . could distinguish and divide
A hair, 'twixt south and southwest side.

Nor would the admiration of the ingenuous one be lessened were he to enter the sanctum of the "professor" of phrenology, and submit his cranium to the ocular inspection and digital manipulation of the oracle. The very furnishings of the apartment are mystic, and impress

or overawe the inquiring mind. Pope's dictum concerning "the proper study of mankind" embellishes the walls; and the advice "know thyself," meant to be interpreted and taken in a phrenological sense, is given gratis through the medium of a conspicuous and usually illustrated poster. The tattooed head of a New-Zealander; a few skulls, occasionally supplemented by a collection of stuffed lizards and other reptilian curiosities, and invariably flanked by busts of the ancient philosophers, complete the æsthetic furnishings of the modern temple of the delineator of character. To the proprietor, in due time, enters a certain moiety of the British public in search of knowledge. And thence issue the patients, each provided for a consideration with a wondrous chart of their mental disposition, wherein the moral quicksands are presumed to be duly marked, and the obliquities of character stamped, with a view toward future correction and improvement.

How does the phrenological professor succeed very fairly in reading character? may be asked at the outset by readers who have had those parts of their disposition best known to themselves delineated with accuracy by the oracle. The reply is clear. Not through manipulating those mysterious "bumps," nor through any occult knowledge of the brains of his votaries, but simply from a shrewd talent for scanning the personal appearance and physiognomy of his clients, and by the dexterous suggestion of queries bearing on those traits of character which the features and manner reveal. Your successful phrenologist is in truth a shrewd physiognomist. His guide to character is in reality the face, not the brain-pan. The dress, manners, and deportment of his clients, and not the gray matter of the cerebrum, form the real basis of his observations. If any one may be found to doubt how accurately one's character may be mapped out from its outward manifestations, let him endeavor to study for a while the acts and deportment of those with whose "mind's construction" he may be even slightly acquainted, and he will speedily discover numerous clews to the mental disposition in common acts and traits which previously had passed utterly unnoticed. Such a result accrues speedily to the professed physiognomist and shrewd observer of men, who, passing his fellows in professional review before him, speedily discovers types of character to which, with allowance for special proclivities or traits, his various clients may be referred. That character may with tolerable success be determined even from handwriting is a well-known fact; and it is difficult to see the superiority of the pretensions and claims of phrenology as a guide to character over those of the professor of calligraphic philosophy. One of the most convincing illustrations that even a practical knowledge of brain-structure is not necessary for the successful delineation of such superficial traits of character as can alone be determined by the casual observer, may be found in the fact that very few "professors" of phrenology have ever studied the brain, while a large proportion may never have seen an actual brain. A notable example of a successful practice of phrenology

being carried on independently of any knowledge whatever of the brain, is known to the writer, in the case of a worthy police-sergeant, who attained tolerable accuracy in the art of reading "the mind's construction," but who had never even seen a brain, and who had the faintest possible idea of the appearance of that organ. Unless, therefore, one may logically maintain that total ignorance of the brain-pan is compatible with an accurate understanding of its contents and mysteries, the successful practice of phrenology must be shown to depend on other data and other circumstances than are supplied by anatomy and physiology—these sciences admittedly supplying the foundation of all that is or can be known regarding the brain, its conformation, structure, and functions. Empirical science—science falsely so called—will not hesitate to assert its ability to accurately solve the deepest problems of character and mind. But the more modest spirit of the true scientist will hesitate before crediting itself with any such ability, or even before giving assent to such general rules of character as are exemplified by the saying, "Big head and little wit"; or by that of the worthy Fuller, who, in his "Holy and Profane State," remarks that "often the cockloft is empty in those whom Nature hath built many stories high."

The fundamental doctrine of the old phrenology is well known to most of us. Its great doctrine is pictorially illustrated in the china heads of the opticians' windows, and may be summed up in the statement that different parts or portions of the brain are the organs of different faculties of mind. The brain thus viewed is a storehouse of faculties and qualities, each faculty possessing a dominion and sphere of its own among the cerebral substance, and having its confines as rigidly defined as are the boundaries of certain actual provinces in the East, the status of which has afforded matter for serious comment of late among the nations at large. Thus, if phrenology be credited with materializing mind in the grossest possible fashion, its votaries have themselves and their science to thank for the aspersion. If it be maintained that feelings of *destructiveness* reside above the ear, then must we localize the desire to kill or destroy in so much brain-substance as lies included in the "bump" in question. When vainglory besets us, we must hold, if we are phrenologists, that there is a molecular stirrage and activity of brain-particles beneath a certain bump of "self-esteem" situated above and in front of the ear; while feelings of veneration, of hope, or of wonder, are each to be regarded as causing a defined play of action in particular bumps and special quarters of the brain. Were the deductions of phrenology true, or were its claims to be regarded as a science founded on definite grounds, mind could no longer be regarded as a mystery, since it would be within the power of the phrenologist to assert that, when swayed by emotions of one kind or another, he could declare which part of the brain was being affected. This declaration logically follows upon that which maintains the localization of faculties

in different parts of the brain ; but it is a conclusion at the same time from which Physiology simply retires in outspoken disdain, as presenting us with an empirical explanation of mysteries to which the furthest science has as yet failed to attain.

That we may duly understand, not merely the falsity of the old phrenology, but the bearings of the new aspects of brain-science as revealed by modern physiology, we must briefly glance at the general conformation of the brain. The organ of mind, contained within the skull, consists of the greater brain or *cerebrum* (Fig. 1, *A A*), and the lesser brain or *cerebellum* (*B*). The latter portion is situated at the

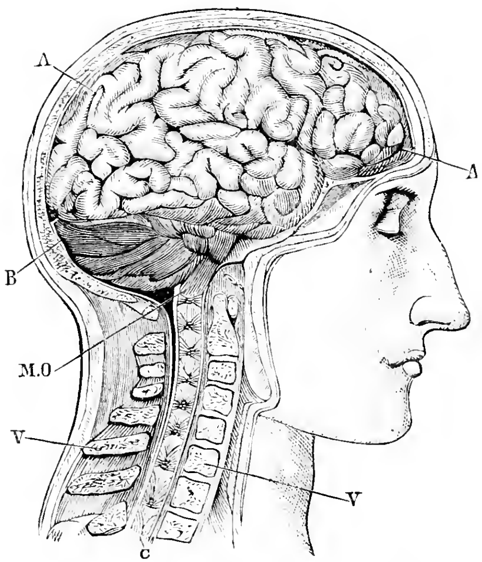


FIG. 1.—SIDE VIEW OF THE BRAIN AND SPINAL CORD.—(From Bourgery.) *A*, the cerebrum; *B*, the cerebellum ; *M.O.* the medulla oblongata ; *V*, the vertebræ, cut in halves ; *C*, the spinal cord, and the origin of its nerves.

back of the head, and forms the hinder part of the brain ; the spinal cord (*C*), which, as every one knows, runs through the spine (*V V*), being merely a continuation of the main axis of the nervous centers of which the brain is the chief. When the surface of the human brain is inspected, it is seen to present a very unequal appearance, due to the fact that its substance is thrown into a large number of folds or *convolutions* (see Fig. 1), as they are technically named by the anatomist. The brain, or cerebrum, is in reality a double organ, formed of two similar halves or *hemispheres*, which are separated by a deep central fissure, but which are also connected together below by a broad band of nervous matter known as the *corpus callosum*. It is this latter band which brings the halves of the brain into relation with one another, and which thus serves to produce identity and correlation of action between its various parts.

To the nature of the convolutions our especial attention must be directed. The brain-substance consists of gray and white nervous matter. The gray matter forms the outermost layer of the brain-substance, and incloses the white; the opposite arrangement being seen, curiously enough, in the spinal cord. Now, one evident purpose of the convolutions of the brain is to largely increase the amount of its gray matter relatively to the space in which the organ of mind is contained; while the perfect nutrition of the brain is also thus provided for through its convoluted structure permitting a fuller distribution of the minute blood-vessels which supply the brain with the vital fluid. It is a very noteworthy fact that the structure of the gray matter differs materially from that of the white. In the gray matter nerve-cells are found in addition to nervous fibers, the former originating nervous force, while the latter are simply capable of conveying this subtile force. Thus it may be said that it is in the gray matter that thought is chiefly evolved, and from this layer that purposive actions spring. The white matter, on the other hand, merely conveys nerve-force and nervous impressions, and is thus physiologically inferior in its nature to the gray substance. The observations of Gratiolet, Marshall, and Wagner seem to leave no room for doubt that the convolutions of the brain increase with culture, and are therefore more numerous and deeper in civilized than in savage races of men. It is curious, however, to observe that certain groups of quadrupeds are normally "smooth-brained," and possess few or no convolutions. Such are rats, mice, and the rodents or "gnawing" animals at large, and it can hardly be maintained that in those animals intelligence is normally low or instinct primitive—although, indeed, the just comparison of human with lower instincts must be founded on a broader basis than is presented by this single anatomical fact.

A final observation concerning the anatomy of the brain relates to its size and weight as connected with the intelligence. The phrenological doctrine of the disposition of the faculties must be held to include the idea that the larger the brain, the better specialized should be the mental qualities of the individual; the greater the amount of brain-substance forming the good and bad qualities and regions of the phrenologist, the more active should be the mental organization. Now, it is a patent fact that this rule tells strongly against the phrenologist's assumption. True, various great men have had large brains; but cases of great men possessing small brains are equally common, as also are instances where insanity and idiocy were associated with brains of large size. The normal average human male brain weighs from 49 to 50 ounces; man's brain being ten per cent. heavier than that of woman. Cuvier's brain weighed $64\frac{1}{2}$ ounces; that of Dr. Abercrombie 63 ounces; that of Spurzheim, of phrenological fame, 55 ounces; Professor Goodsir's brain attained a weight of $57\frac{1}{2}$ ounces; Sir J. Y. Simpson's weighed 54 ounces; that of Agassiz 53·4 ounces; and that of Dr.

Chalmers 53 ounces. As instances of high brain-weights, without corresponding intellectual endowment, may be mentioned four brains weighed by Peacock, the weights of which varied from 67·5 to 61 ounces. Several insane persons have had brains of 64½ ounces, 62 ounces, 61 ounces, and 60 ounces, as related by Bucknill, Thurnam, and others. With respect to the brain-weights of the fair sex, anatomical authority asserts that in women with brains weighing 55·25 ounces and 50 ounces, no marked intellectual features were noted. Below 30 ounces, the human brain becomes idiotic in character, so that there appears to exist a minimum weight, below which rational mental action is unknown. The anatomist's conclusions regarding brain capacity and mental endowments are therefore plain. He maintains that the size and weight of the organ do not of themselves afford any reliable grounds for an estimate of the mental endowments, while his researches also prove that a large brain and high intellectual powers are not necessarily or invariably associated together.

The foregoing details will be found to assist us in our criticism of the pretensions of the old phrenology as a basis for estimating "the mind's construction" and the mental habits of man. Primarily, let us inquire if development—that great criterion of the nature of living structure—lends any countenance to the idea that the brain is a collection of organs such as the phrenologist asserts it to be. The brain of man, like that of all other backboned animals, appears to begin its history in a certain delicate streak or furrow which is developed on the surface of the matter of the germ. Within this furrow the brain and spinal cord are at first represented by an elongated strip of nervous matter, which strip, as the furrow closes to form a tube, also becomes tubular, and incloses within it, as the hollow of the tube, the little canal which persists in the center of the spinal cord. The front part of this nervous tube, which soon exhibits a division into gray and white matter, now begins to expand so as to form three swellings named *vesicles*. From these vesicles the brain and its parts are formed. The foremost swelling soon produces the parts known as the optic lobes, and also the structures which are destined to form the hemispheres or halves of the brain itself. The middle swelling contributes to the formation of certain important structures of the brain ; and finally the cerebellum or lesser brain, along with the upper part of the spinal cord and other structures, appear as the result of the full development of the hinder or third swelling. Nor must we neglect to note that at first the human brain is completely smooth and destitute of convolutions, and only acquires its convoluted appearance toward the completion of development.

It is now an appropriate duty to inquire if the history of the brain's growth affords any countenance or support to the phrenological division of the organ into some thirty-five different organs and seats of faculties. The query is further a perfectly legitimate one. The phrenolo-

gist maintains the actuality of his deductions respecting the "organs" of mind, and it is only a fair and just expectation that, if the brain be a congeries of such organs, the anatomist should be able to see these parts as development has revealed them. The nature of the brain is asserted by the phrenologist to exist in its composition as a set of organs. That nature, argues the anatomist, if revealed at all, should present itself in its development, which alone can show us nature's true fashion of building a brain. What, therefore, is the result of the anatomist's study of the manner in which the brain is fashioned? The answer is found in the statement that there is not a trace of a single "organ" such as the phrenologist theoretically maintains is represented in the brain. There is no division into separate parts and portions, as the phrenologist's chart would lead the observer to suppose. The scalpel of the anatomist can nowhere discover in the full-grown brain an organ of veneration, or of hope, or of language, or of destructiveness, or of any other mental feature: nor can his microscope detect in nature's wondrous process of fashioning the brain any reason for the belief that the organ of mind is a collection of parts each devoted to the exercise of a special quality of mind. The arrangement which appears so clear on the phrenologist's bust is nowhere represented in the brain itself. And the organs of the phrenologist, in so far as their existence is concerned, may not inaptly be described in Butler's words as being

> Such as take lodgings in a head
> That's to be let unfurnishèd.

But if development gives no support to the phrenological assertion of the brain's division into organs of the mind, neither does anatomy, human and comparative, countenance its tenets as applied to the examination of the brain-pan itself. To select a very plain method of testing the deductions of phrenology, let an anatomical plate of the upper surface of the undisturbed brain be exhibited, and, having settled the position of certain "organs" from a phrenological chart, let any one try to discover if the limits of any one organ can be discerned on the brain-surface. He will then clearly appreciate the hopeless nature of the task he has undertaken, and be ready to shrink from the attempt to resolve the complex convolutions before him into a square inch here of one faculty, or a square inch there of another. Moreover, one very important consideration will dawn upon the reflective mind which considers that the convolutions of the brain are not limited to the crown and sides of the head, but, on the contrary, extend over the entire surface of the cerebrum, and are developed on its base (see Fig. 2). No phrenologist has attempted, it is true, to get at the base of the brain by inspecting the palate; but it would be regarded as an absurd and unwarrantable statement to assert that the base of the brain has no functions, and that the mind of man is located only at the top and on the sides of the head. Yet the phrenologist is in the position of one

making such an assertion, since his science takes no account of the base or internal parts of the brain—situations, forsooth, in which anatomy and the newer phrenology demonstrate the existence of very important sensory and other organs. The question of tho relatively im-

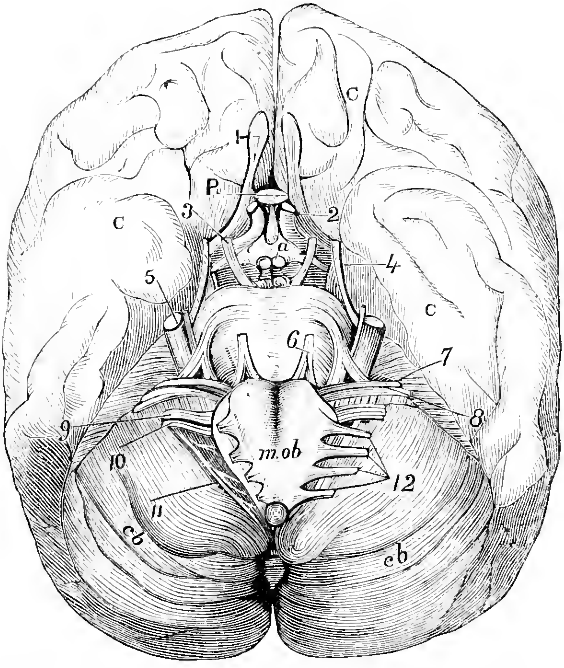


Fig. 2.—The Base of the Brain.—(From Bourgery.) *C*, under surface of the cerebrum; *cb*, the cerebellum; *m.ob*, the medulla oblongata. The nerves are numbered 1 to 12; 1, the olfactory nerve; 2, the optic; 3, 4, and 6, nerves which govern the muscles of the eyeball; 5, the trigeminal, which arises as shown by two roots; 7, the facial; 8, the auditory; 9, the glosso-pharyngeal; 10, the pneumogastric; 11, the spinal accessory; 12, the several roots of the hypoglossal. The figure 6 is placed on the pons varolii; the crura cerebri are between the third and fourth nerves on either side. Just above are *a*, the corpora albicanta, and *P*, the pituitary body.

mense tracts of brain which lie without the utmost ken of phrenology, even on its own showing, is also illustrated by the observation that the bulging or hollowing of the skull at any point affords no criterion of the thickness of the gray matter of the brain, a layer which we have already seen to constitute the most important part of the brain-substance. This gray matter is seen to exist in tolerable uniformity over large tracts of brain-substance, and it is invariably in the hinder region of the brain that it attains its greatest complexity and development. The form of the skull is dependent on the amount and disposition of the white matter, and not on that of the gray; and the former, as we have seen, has but a minor influence or part in the mental constitution, since its function is merely that of conducting and not of originating thoughts and impressions. Since, then, phrenology lays so much stress on skull-conformation as a clew to brain-structure, it must

be regarded as dealing rather with the results of the disposition of the white matter than with that of the gray—and this latter assumption of necessity involves a second, namely, that phrenology has no status as a science of mind at all.

There is one consideration concerning the practical application of the phrenologist's assertions too important to be overlooked, namely, the difficulty of detecting or of mapping out on the living head the various "bumps" or organs of mind which appear to be so lucidly localized on the bust or chart. The observer, who might naturally think the determination of the "bumps" an easy matter, has but to try to reconcile with a phrenological chart, or with the brain-surface itself (Fig. 1), the configuration of a friend's cranium, and he will then discover the impossibility of distinguishing where one faculty or organ ends and where another begins. How, for instance, can the exact limits of the four or five organs of mind, to be hereafter alluded to more specifically, which are supposed to exist in the line of the eyebrow, be determined? What is the criterion of excessive or inferior development here, and how may we know when one "encroaches" upon another to the exclusion or atrophy of the latter? The practical application of phrenology indeed constitutes one of its difficulties; and added to the difficulty or impossibility of accurately mapping out the boundaries of the phrenologist's organs, we must take into account the fact that we are expected to detail these organs through, in any case, a considerable thickness of scalp, which veils and occludes, as every anatomist knows, the intimate conformation of the skull-cap. At the most the phrenologist may distinguish regions; his exact examination of the living head *à la* phrenological chart or bust is an anatomical impossibility.

But the anatomist has also something of importance to say regarding the actual existence of certain of the "organs" of mind mapped out by the phrenologist. Leaning trustfully upon their empirical deductions, the phrenologists have frequently localized faculties and organs of mind upon bony surfaces separated from the brain by an intervening space of considerable kind. In so far as comparative anatomy is concerned, phrenology receives no assistance in its attempt to localize mind-functions in man. An elephant is admittedly a sagacious animal, with a brain worth studying; just as a cat or tiger presents us with a disposition in which, if brain-science is applicable, as it should be, to lower forms of life exhibiting special traits of character, destructiveness should be well represented and typically illustrated. Alas for phrenology! the bump of destructiveness in the feline races resolves itself into a mass of jaw-muscles, and the elephant's brain is placed certainly not within a foot or so of the most skillful of phrenological digits. The "frontal sinuses" or great air-spaces in the forehead bones of the animal intervene between the front of the brain, the region *par excellence* of intellect according to phrenology, and the outside

layer of the skull. So that an observer could no more accurately construct a phrenological chart of an elephant than he could diagnose the contents of a warehouse by scanning the exterior of the building.

Not merely, however, are the difficulties of phrenology limited to the lower animals. Suppose we make a cross-section of a human skull through either the right or left side of the forehead, about half an inch above the upper border of the orbit or eye cavity. We may then discover that man as well as the elephant possesses "frontal sinuses" or air-spaces in his forehead-bone of considerable extent intervening between the exterior of the skull and the contained brain. Now, in such a section of the human skull, what phrenological "organs" shall we cut through? Certainly those of "individuality," "form," "size," and "color." In placing such organs across the eyebrows, the phrenologist might naturally be regarded as having proceeded on the assumption that he was mapping out on the exterior of the skull a certain part of the brain-surface. What shall be said of his procedure, however, when the reader learns that a section of the skull made as indicated through these organs shows that they—i. e., the "organs" as marked on the outside of the skull—overlie the hollow spaces or "frontal sinuses," and are actually separated from the brain by cavities of considerable extent, in some cases exceeding an inch? Such a demonstration truly speaks for itself, and no less so does the anatomist's discovery that the "organ" of phrenologists known as "form" actually reposes in anything but a noble position on the cavity of the nose; that the organ of "calculation" is a solid bony (*orbital*) process; and that the size of the organ of "language" really depends upon the want of forward projection of the eye depending on the special development of a bony process on which the organ of sight rests, and which in any case has nothing whatever to do with the brain. Of language more anon; but enough has been said to show that a connection with the brain is not an invariable or apparently necessary condition for the construction of a phrenological "organ" of the mind—the fact that the brain is the organ of mind notwithstanding.

But neither does the case for phrenology fare any better when it is tested by the results of the examination of crania belonging to persons whose family or personal history was well known, and whose characters, in respect of their thorough and stable formation, would therefore serve as a test of phrenological or any other system of mind-explanation. In the heyday of phrenological discussion, and in Edinburgh as the very focus and center of the arguments *pro* and *con* the system of Gall and Spurzheim, a Mr. Stone, then President of the Royal Medical Society, read in 1829 a paper in which the results of a most laborious and conscientious series of observations on the crania of well-known persons were detailed. These results, as will presently be shown, were fatal to any ideas which might have been entertained regarding the authentic nature of the data on which phrenological observations were founded.

Fifty skulls were selected for measurement from the famous collection of Sir William Hamilton, fifty others being taken from that of Dr. Spurzheim himself. In the case of the skulls of fifteen murderers, whose crimes had been marked by unusual brutality and violence, and who might therefore be regarded as exemplifying cases in which the largeness of the "organ" of destructiveness might be lawfully postulated by a phrenologist, Mr. Stone demonstrated by careful measurement and comparison that each of the fifteen had the organ or surface of "destructiveness" *absolutely less* than the average of ordinary heads, while thirteen of these skulls possessed this organ *relatively less* when compared with the whole contents of the brain-pan. Nor was this all. Thirteen of these fifteen worthies possessed a larger organ of "benevolence" than the average, and their "conscientiousness" was also as a rule well developed. Their brains were not markedly deficient in front of the ear—the region of the intellectual faculties, according to the phrenologist—nor were they unusually developed behind the ear, where the animal faculties are supposed to reside.

No less instructive were the comparisons instituted between the faculties of Dr. David Gregory, once Professor of Mathematics in the University of Edinburgh, and Savilian Professor of Astronomy at Oxford, a friend and contemporary of Sir Isaac Newton. Professor Gregory's character was well known as that of an amiable, accomplished, intellectual man. In such a case the moral faculties would be expected to present high development, while the animal faculties and baser qualities would naturally be regarded as being but poorly represented. Mr. Stone's measurements, duly verified by independent observers, elicited the awkward fact that Dr. Gregory should, according to the phrenological interpretation of his cranium, have ranked in the criminal category, since his organ of "destructiveness" was found to exceed in size that of every murderer in the collection under discussion! In proportion to the general size and form of the brain, Dr. Gregory's "destructiveness" was larger than that of the notorious Burke, who was executed at Edinburgh for the cold-blooded murder of men, women, and children, whose bodies, along with his coadjutor Hare, he sold for purposes of anatomical inspection. Not to enumerate in detail the startling results which the fair and unbiased examination of Dr. Gregory's cranium afforded, it may simply be mentioned that the Professor's "combativeness" was larger than that of any of the debased villains with whom his faculties were compared. Burke equaled him in "benevolence"; in "secretiveness" he excelled the noteworthy fifteen; his "acquisitiveness" exceeded that of Haggart and other noted thieves; his "causality"—the power of reasoning closely, and of tracing the relations between cause and effect, a faculty which as a mathematician he should have possessed largely developed—was less than that of the criminals; and his intellectual faculties at large were of less capacity than theirs, as his animal faculties were present in greater force.

No further illustration is required of the fact that, tested under exceptionally favorable circumstances, the deductions of phrenology are absolutely incorrect, not to say absurd. Nor is the case of the phrenologists bettered by their exercise of apologetics in face of the hard logic of the above and similar facts. Thurtell, with very large "benevolence" and with well-developed "veneration," yet committed an atrocious murder, and this without a special development of "destructiveness." "Nothing can justify the murder," said the phrenologists, but Thurtell imagined that he would "do a service to society by killing his friend" (where his benevolence?) "and hence his crime." Thus benevolence, by the exercise of phrenological apologetics, becomes an excuse for and an active cause of murder. Dr. Gregory's "destructiveness," said the phrenologists, was held in check by some other qualities—by which qualities it would be hard to say, seeing that, tested by phrenology, his whole mental and moral organization was below that of the average murderer. So that we are to believe, in short, that "destructiveness," and the other base qualities of the Professor, being absolutely useless, must have been intended simply for show and not for use. Things, on this reasoning, truly are not what they seem; and phrenology thuswise cuts away from under itself its fundamental propositions, that its "organs" are the seats of faculties, and that their activity is proportional to their size.

But to proceed further would be to slay the slain. Thus much indeed we have said of the phrenology which still lingers in our midst, by way of contrast with the newer order of brain-interpretation which the advance of physiology has caused to arise among us. In the early days in which the battle of phrenology was fought and won as against the science of brain-pans, physiological experimentation upon the brain was an unknown and unworked source of information. In due time came Flourens, Magendie, Fritsch, Hitzig, and Ferrier, with their exact methods and results, enlarging the conceptions of the brain and its powers, and throwing here and there a ray of light upon the dark places and hidden corners in the domain of the physiology of mind. Hence our new "phrenology"—for the word itself is perfectly explicit as denoting a science of mind or brain—is gradually being built up from sure data and accurate experimentation, the results arrived at by one worker being tested by a host of fellow-experimenters ere his inferences become facts, and before they are allowed to form part and parcel of the scientific edifice. Let us briefly see what are the more prominent facts concerning the brain and its functions which recent science has elucidated.

No part of the brain has perhaps presented problems of such interesting character as the *cerebellum* or lesser brain which, as already remarked, exists at the hinder and lower part of the head, and which moreover presents us with a structure differing from that of the cerebrum itself. Phrenologists located in the cerebellum the purely animal

faculties. "A man," as we remember hearing a phrenological lecturer say, "with a head bulging out behind, is going backward in the world"; and there was indeed, as we shall see, a modicum of truth (although he knew and understood it not) in the lecturer's remark, since without the cerebellum we could in reality proceed neither forward nor backward. We now know that the old phrenology of the cerebellum is utterly wrong and unfounded. The new phrenology has shown us that in cases of diseased animal appetites, which in our lunatic asylums are but too frequently represented, the cerebellum is not found to be affected—a result explained by the fact that the appetites referred to are indeed as much part of our "mental" constitution as is the exercise of benevolence or of any other mental faculty. Furthermore, the new phrenology supplies positive evidence as to the true functions of the cérebellum. When it is removed from a pigeon, for instance, the animal retains its faculties, it will feed, it can see and hear, but is utterly unable to maintain its equilibrium. If thrown into the air, it flaps its wings in an erratic and aimless fashion. In one word, it can not "coordinate" its movements, that is, it can not so adjust the motions of one set of muscles as to bring them into purposive harmony with another set or series. The cerebellum thus appears to be the great brain-center whence are issued the commands and directions which guide the muscular actions and movements of our lives. Contrariwise, the true functions of the cerebellum are proved by experiments in which this part of the brain has been left intact while the cerebrum or true brain has been removed—an operation absolutely painless, as will presently be more particularly mentioned. A bird or higher animal in such a case will lose all power of volition; it will be deprived of sight, hearing, and other senses; it will die of hunger unless fed; it will exhibit no desire to move; and will in short present a condition utterly opposed to that seen when the cerebellum is removed and the true brain left intact. But with its cerebellum present, and *minus* its true brain, the bird can perfectly "coördinate" its movements. It will fly straight if thrown into the air, it will walk circumspectly enough if pushed forward, and will exhibit in fact such perfect muscular control, despite its want of volition and intellect, that the functions of the cerebellum as a controller of movements are no longer matter of hypothesis, but have become stable physiological fact.

If, however, the old phrenology has been displaced from the cerebellum by the new, no less important is it to note that, regarding the functions of the true brain, modern research has been equally successful in deposing the old ideas of the "organs" and their attendant faculties as exhibited on the phrenological charts and busts. Experimentation on the brain of higher animals, *quoad* the brain itself, is absolutely painless—contrary to popular notions and ideas. True, there are certain parts of the brain which are exceedingly delicate, and in which the point of a needle would inflict at once a fatal injury. But the

brain-substance itself is utterly non-sensitive, as every hospital-surgeon can tell us. Persons may actually recover from serious injuries of the brain in which several ounces of brain-substance may have been lost, and recover with good effect, and in many cases without any perceptible alteration of their mental peculiarity. The most notorious case of this kind is known as "the American crow-bar case." A bar of iron accidentally shot off from a blast passed through the top of a young man's head at the left side of the forehead, having traversed the front part of the left hemisphere or side of the brain. The iron bar measured three feet in length, and weighed fourteen pounds. After the accident he felt no pain, and was able to walk without help in a few hours' time. The man made a good recovery, and for twelve years made a livelihood by exhibiting himself in the United States, his skull being now preserved in the museum of Harvard University. This patient undoubtedly lost a relatively large portion of his brain-substance. At one fell swoop there must have been a considerable destruction of phrenological organs. Yet he suffered from no deprivation of intelligence; and few would dream of associating the drinking habits which finally beset him with his accident and with his loss of brains, or otherwise maintain that he was less rational before than after the accident. Thus the misfortunes of existence and the experimentation of the physiologist positively contradict the old phrenology, and assert that localization of function does exist, it is true, but that the "organs" of the phrenologist are mere theoretical nonentities, without a trace of substance to insure their stability or real nature.

What amount of localization, then, can be safely assumed to exist in the human brain as revealed by recent experimentation? It may be known to the generality of readers that the movements, acts, and probably ideas relating to one side of the body are regulated by the opposite side or hemisphere of the brain. Thus, convulsions affecting one side of the body were shown by Dr. Hughlings Jackson to be caused by disease of the opposite side, and the idea of the duality of the brain's action followed in a natural sequence on the observation of facts like the preceding. Thus, as a general rule, it may be affirmed that brain-disease itself, or the ideas of natural existence, are so far localized that their perfect effects are only visible and appreciated when the same parts in both halves or hemispheres of the brain are affected. To illustrate what the new phrenology has to say regarding the localization of the brain-functions, let us inquire what is known regarding the exceedingly curious condition known as "aphasia." Persons affected with this lesion understand perfectly what is said to them, but they are absolutely speechless, and can not utter a single word. Now, it is a perfectly well-ascertained fact that aphasia is associated with disease of the front part of the *left* half or hemisphere of the brain—a part which may therefore be called the "speech-center." The curious fact must thus be emphasized that aphasia is invariably associated with disease

of the left, and never with disease of the right side of the brain. To the brief explanation of this curious fact we shall presently return ; but we may in conclusion remark certain facts now known respecting the localization of other functions. Professor Ferrier, of King's College, London, employing electricity as the only agent and means of stimulation to which the non-sensitive brain will respond, has succeeded in mapping out in the brains of higher animals the centers which govern many of the common movements of life, and which from reasonable analogy may be presumed to be represented in the human brain as well. As these acts are the practical outcome of ideas, the parts of the brain concerned in the production of definite ideas may thus be regarded as being in one sense mapped out and recognized ; although it is hardly necessary to remark that the regions of Dr. Ferrier in no wise correspond to those of the old phrenology, while in many cases, indeed, they are utterly opposed to it. Thus the sense of touch is found to be localized in the inner surface of the hemispheres of the brain, and this fact alone tells against the phrenologist, to whom the mere brain-surface is the brain itself.

Thus the work of localizing movements and important centers of the senses has so far proceeded with success. There yet remains for observation the curious case of aphasia or speechlessness, and its location in a "speech-center" or "speech-organ" in the front of the left hemisphere of the brain. It is a noteworthy fact in brain-physiology, that when an animal has been rendered blind by the destruction of the sight-center of one side, blindness disappears and sight gradually returns, since the remaining and normal sight-center of the opposite side assumes the functions of its neighbor. Complete blindness only ensues when both sight-centers are diseased. The same remark holds good of the movements of the mouth and tongue in speech, these being "bilateral," so that the center of these latter movements on one side may be destroyed without causing paralysis of the tongue, provided the center of the other side is uninjured. Movements of the hands and feet are, on the contrary, one-sided. Destruction of one center governing these latter movements insures complete cessation of the movements on the opposite side of the body. Now, in aphasia or speechlessness, we merely perceive the results of the destruction of the single speech-center—the left—which man normally possesses. Just as we use the right hand in preference to the left in prehension and in writing, and as the movements of this hand are regulated by the left side of the brain, so our faculty of articulation is also unilateral and single-handed, so to speak. The memory of sounds and words forms the basis of our speech —"the memory of words is only the memory of certain articulations" —and those parts of the brain which regulate articulation are also the memory-centers for speech or the result of articulation. Thus, when the speech-center is disorganized, not merely the power of articulation disappears, but also the memory of words. But while the left side is

that of the speech-center, there is no reason, as Dr. Ferrier remarks, apart from heredity and education, why this should necessarily be so. "It is quite conceivable," says this author, "that a person who has become aphasic by reason of total and permanent destruction of the left speech-center may reacquire the faculty of speech by education of the right articulatory centers." We speak with the left side of our brains, in short, not because we are unable to do so with the right side, but simply because habit and the law of likeness together strengthen and perpetuate the custom of speaking with the left. But it may be also supposed that, as a left-handed person must regulate the movements of his arms chiefly by the right side of his brain, so there may exist subjects who naturally use the right instead of the left speech-center.

Whatever results may in future accrue to human knowledge from researches into the functions of the brain, no one may doubt the all-important nature of the knowledge which literally enables man to know himself, and to understand in some degree the mainsprings of the actions which constitute his daily existence. The subject is also no less instructive in the sense in which it shows the displacement of erroneous ideas by new and higher thoughts founded on accurate observation of the facts of life; while in a very direct fashion such higher knowledge may affect suffering humanity, since an educated medical science, furnished with secure data regarding the causes of mental affections, may successfully "minister to minds diseased," and even in due time raze out the troubles which perplex many a weary soul.—*Gentleman's Magazine.*

BACKGAMMON AMONG THE AZTECS.

By EDWARD B. TYLOR.

BY *backgammon* we usually mean one particular game played with dice and thirty draughts, on a board with twelve points on each side. But this is only one of a family of games, whose general definition is that they consist in moving pieces on a diagram, not at the player's free choice, as in draught-playing, but conformably to the throws of lots or dice. It can hardly be doubted that the set of games thus combining chance and skill are all, whether ancient or modern, the descendants of one original game. By a stretch of imagination, it may be possible to fancy draughts or dice to have been fresh invented more than once. But, when it comes to a game which combines the two ideas, it seems to pass the bounds of ordinary probability to suppose, for instance, that a Greek and an Arab and a Birmese were separately seized by the same happy thought, and said, "Go to, let us cast lots, and count them to play at draughts by." If indeed any reader should think such a combination might have happened twice over, he

may be asked to look closely into the games presently to be described, so as to satisfy himself that their agreement goes even further, as in the peculiar principle on which the high and low throws are counted, and, so far as one knows, in there generally being in some shape the rule of hitting a blot, that is, taking an enemy's undefended man off the point one's own man moves to. The exact primitive game whence all known games of the class were derived can not now be pointed out, and indeed is perhaps lost in prehistoric antiquity. So we may as well keep to our own word, and call the whole set the backgammon family. It is in this sense that I use the word here, with the purpose of proving that, before Hernando Cortes landed with his invading Spaniards at Vera Cruz, one variety of backgammon had already found its way over from Asia into Mexico, and had become a fashionable amusement at the barbaric court of Montezuma. But, before following the game on its hitherto unnoticed migration into the New World, let us first glance at its Old World history.

Clearly our English *backgammon* and the more complicated French *trictrac* are descended from the Roman game of the "twelve lines" (*duodecim scripta*), which was played throughout the empire. This is the game which Ovid says has lines as many as the gliding year has months, and he means it where he gives the lover insidious counsel, when his mistress casts the ivory numbers from her hand, let him give himself bad throws and play them ill. Among the Christian antiquities in Rome is a marble slab, on which a backgammon-table is cut, with a Greek cross in the middle, and a Greek inscription that Jesus Christ gives victory and help to dicers if they write his name when they throw the dice—Amen. Carelessly scratched as it is, by some stone-cutter whose faith went beyond his trictrac, it shows that the board was like ours even to the division in the middle, which makes the two groups of six points on each side. From ancient Rome, too, we inherit the habit of making the backgammon-board with a draught-board on the reverse side, at any rate the commentators so interpret Martial's epigram on the *tabula lusoria:*

> *Hic mihi bis seno numeratur tessera puncto*
> *Calculus hic gemino discolor hoste perit.*

> Here, twice the die is counted to the point of *size*,
> Here, 'twixt twin foes of other hue, the draughtsman dies.

The very mode of playing the men in classic backgammon may be made out from a fifth-century Greek epigram, commemorating a remarkable hit, in which the Emperor Zeno got his men so blocked that, having the ill-luck to throw 2, 5, 6 (they used three dice, as indeed we continued to do in the middle ages), the only moves open obliged him to leave eight blots. This historic problem, and other matters of Greek and Latin backgammon, are worked out by M. Becq de Fouquières, in his "Jeux des Anciens," with a skill that would have rejoiced the hearts

of those eminent amateurs, the old Count de Trictrac and the venerable Abbé du Cornet, to whose teaching history records that Miss Becky Sharp ascribed the proficiency at backgammon which made her society so agreeable to Sir Pitt at Queen's Crawley.

It is not known so exactly what manner of backgammon the Greeks played in earlier ages; but there are various passages to prove that, when they talk of dice-playing, they often mean not mere hazard, but some game of the backgammon sort, where the throws of the dice are turned to account by skillful moving of pieces. Thus Plato says that, as in casting dice, we ought to arrange our affairs according to the throws we get, as reason shall declare best; and Plutarch, further moralizing, remarks that Plato compares life to dicing (*κυβεία*), where one must not only get good throws, but know how to use them skillfully when one has got them. So with Plutarch's story of Parysatis, mother of Artaxerxes. She was "awful at dice" (*δεινὴ κυβεύειν*), and, "playing her game carefully," won from the king the eunuch Mesabates, who had cut off the head and hand of Cyrus; having got him, she had him flayed alive and his skin stretched. This episode of old Persian history is noteworthy in the history of the game, because Persian backgammon, which they call *nard*, is much like the European form of the game, which, it has not been unreasonably guessed, may itself have come from Persia. This nard is popular in the East, and orthodox Moslems have seen in the fateful throws of the dice a recognition of the decrees of Allah, that fall sometimes for a man and sometimes against him. It is, said one, a nobler game than chess, for the backgammon-player acknowledges predestination and the divine will, but the chess-player denies them like a dissenter. Not to lose ourselves in speculations on the Oriental origin of backgammon, at any rate it was from Rome that it spread over Europe, carrying its Latin name of *tabulæ* with it in French and English *tables*. This word has dropped out of our use since the Elizabethan period, but an instance of it may be cited in a couple of lines, conveying another little sermon on backgammon, which the English author no doubt borrowed from the Latin of Terence, even as he had copied it from the Greek of Menander:

> Man's life's a game of *tables*, and he may
> Mend his bad fortune by his wiser play.

There is an idea which readily presents itself as to how backgammon came to be invented, namely, that the draughts were originally mere *counters*, such as little stones, shifted on a calculating board to reckon up the successive throws, and that it was an afterthought to allow skill in the choice of moves. This guess fits well enough with the classic draught being described as a stone, *ψῆφος*, *calx* or *calculus*, while in Germany, though now made of wood, it still keeps its old name of *stein*. Also the playing board on which the stones were moved shares the name of the calculating board, *ἄβαξ*, *abacus*. But if the classical

varieties of backgammon in this way show traces of the game near its original state, they seem in another respect to have passed out of their early simplicity. They are all played with dice, and indeed the French author lately mentioned seems right in guessing that the division of our board into groups of six points each was made on purpose to suit the throws of cubical dice like ours, numbered on all the sides, from 1 to 6. As to the early history of dice, I have elsewhere endeavored to show ("Primitive Culture," chapter iii.) that the origin of games of chance may be fairly looked for in instruments of the nature of lots, at first cast seriously by diviners for omens, and afterward brought down from serious magic into mere sport. Now, the simplest of such instruments is the lot which only falls two ways, like the shell, white on one side and blackened on the other, which Greek children spun up into the air to fall, "night or day," as they said; or, like our half-pence, tossed for "head or tail." Both in divination and in gambling, such two-faced lots probably came earlier than the highly artificial numbered dice. The kinds of backgammon now to be described seem in general to belong to the earlier stage of development, for it is with lots, not dice, that they are played.

The traveler in Egypt or Palestine now and then comes on a lively group sitting round a game, and in their eager shouts, if he knows some Arabic, he may distinguish not only such words as "two" or "four," but also "child," "dog," "Christian," "Moslem. On closer examination he finds that the game is called *táb*, and that it is a sort of backgammon played on an oblong checker-board, or four rows of little holes in the ground, where bits of stone on one side and bits of red brick on the other do duty as draughts, being shifted from place to place in the rows of squares or holes. Not dice, but lots, are cast to regulate the moves; these lots are generally four slips of palm-stick, with a green outer side and a white cut side (called black and white), and when they are thrown against a stick set up in the ground, the throw counts according to how many white sides come up, thus:

Whites up:	None	One	Two	Three	Four.
Count:	6	1	2	3	4
	(go on)	(táb)	(stop)	(stop)	(go on)

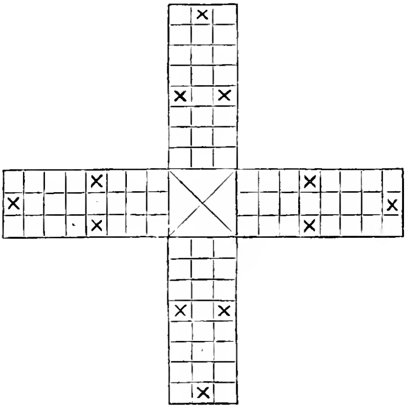
Notice particularly this way of counting throws, for its principles will be found again in lot backgammon elsewhere. There is evidently a crude attempt to reckon probabilities, giving a higher value to the less frequent throws of all four white and all four black, than to two or three white, which come up oftener. Besides the high count, they have the privilege of a second throw. This, if lot backgammon came first, and was succeeded by dice backgammon, would naturally pass into our rule of giving doubles another throw. The throw of one white, which is called "child," or *táb*, i. e., "game," has a special power, for only by it may a "dog," that is, a stone or draught, be moved out of its original place in the outer row, and set at liberty to circulate along the lines of

squares or "houses," taking an enemy's dog if found alone in its house. While a draught is still in its first inactive, useless condition, they call it a "Nazarene," or Christian; but, when the throw of *táb* gives it the right to go forth conquering and to conquer, it becomes a "Moslem." It is not needful to go further into the rather complicated rules of moving and taking. Those who are curious may find much about it in Lane's "Modern Egyptians," and in the quaintly learned little book "De Ludis Orientalibus," by Thomas Hyde, who was Bodleian librarian in the reign of William and Mary. But one question suggests itself. Seeing how the modern fellahs delight in *táb*, one naturally asks, Did they inherit it from the ancient Egyptians? From remote antiquity the Egyptians played draughts on earth, and after death their righteous souls still had the oblong checker-board, and the men like chess-pawns, to amuse their glorified but perhaps rather tiresome life in the world below. But, as Dr. Birch points out, no Egyptian dice have been found earlier than Roman times, nor any plain mention of backgammon. Even if they played like their descendants in the Nile Valley with such things as slips of palm, something about it should be found in the hieroglyphic texts. But at present nothing appears, and there is no reason to add backgammon to the long list of inventions whose earliest traces are found in Egypt. Perhaps the nearest relative of *táb* is Chinese backgammon, but this is played with dice.

Next, as to India. Here, since ancient times, cowry-shells have been thrown as lots, their "head" and "tail" being according as the shell falls with mouth or back upward. In Sanskrit literature there is an old mention of a game called *panchikâ*, which was played with five cowries, and where it seems that the winning throws were when all the mouths came up or down, as against the commoner throws when some fell each way. That a game of the nature of backgammon was known in India from high antiquity has been plainly made out by Professor Weber. It was called *ayânaya*, or "luck and unluck"; or at any rate that was a term used as to the moving of the pieces, which traveled right and left through the squares, and took an undefended man from his place to begin his course anew. So, as a Sanskrit riddle has it: "In a house where there were many, there is left but one, and where there was none and many come, at last there is none. Thus Kâla and Kâlî, casting day and night for their pair of dice, play with human beings for pieces on the board of the world." Putting these particulars together, it is clearly possible to trace from ancient times the game of *pachisi*, played in modern India, into which game it will now be necessary for our argument to go more exactly; in fact, to qualify ourselves to sit down and play a game. English backgammon-players will hardly take five minutes to learn it.

Suppose four players to be seated, each at the end of one arm of the diagram or board, of which a figure is here given. Each player will have four little wooden cones as his pieces or draughts, all of one

color, to distinguish them. If only two play, each will manœuvre two sets of men. Each player's men start one by one down the middle row of his own rectangle, beginning with the square next the central space, and thence they proceed all round the outside rows of the board, traveling from right to left (contrary to the sun) till they get back to their own central row, and up it home to where they started from, he who first gets all his men home winning the game. A solitary man is taken up and sent back to begin again, by one of his adversary's men lighting upon his square, except in the case of the twelve privileged squares, which are marked with a cross, in which case the overtaking piece can not move. The moving is determined by throwing a number of cowries, which count according to how many fall mouth up; thus, if six cowries are used:



Mouths up:	None	One	Two	Three	Four	Five	Six.
Count:	6	10	2	3	4	25	12
	(go on)	(das)	(stop)	(stop)	(stop)	(pachisi)	(go on)

According to the rules kindly sent me from Dr. Rajendralala Mitra, of Calcutta, the throws of one-up or five-up (*das* or *pachisi*) alone can start a man on his first square, or get him off if stuck on his last square. These throws, as well as none-up and six-up, give a new throw. Thus the best beginnings are one-up followed by two-up, or five-up followed by four-up, either of which enters a man and carries him on in safety into a "fort." Seven cowries can also be used, but the primitive game was probably more like the ancient game with five cowries just mentioned, for the name pachisi means "five-and-twenty," and was no doubt taken from the throw when five shells come up. The principles of counting the throws and entering the men are plainly like those in the Arab game of táb, and there are Indian forms with only four cowries which come still closer.

Pachisi is a favorite game in India, and an eager player will carry rolled round in his turban the cloth which serves as a board, so as to be ready for a game at any moment. These cloths, when embroidered with the diagram in colored silk, are quite artistic objects, and one does not often see prettier toys than a set of men in Mr. Franks's collection, little cones (or rather sugar-loaves) of rock crystal, with the colors they are to bear in the game shown by mounting in the top a ruby for red, an emerald for green, etc. There are even stories of yet more

sumptuous games, where the board was a courtyard laid out in marble pavement, on which living draught-men clothed in green, red, yellow, and black, walked the circuit and hustled one another off the squares. Our Anglo-Indians sometimes catch the enthusiasm; and there is an often-told tale of that official personage who, when he paid his native servants their wages, would sit down with them to a match at pachisi, and sometimes win his money back. In London toy-shops they sell board and pieces for what they profess to be the game, but these really belong to the modified form of it known in India as *chûpur*, in which, instead of cowries, stick-dice numbered on the four long sides are thrown, these Indian dice being in England replaced by our common cubical ones. This shows the change from lots to dice in games of the backgammon sort, and it is curious to notice how clearly the new rules for counting by the dice are modeled on the old rules for throws of cowries. Having now sufficiently mastered the peculiarities of pachisi, let us pass from Asia to America, and compare them with the details of the Mexican game of *patolli*.

When the Spanish invaders of Mexico gazed half in admiration and half in contempt on the barbaric arts and fashions of Aztec life, they particularly noticed a game, at which the natives played so eagerly that, when they lost all they had, they would even stake their own bodies, and gamble themselves into slavery, just as Tacitus says the old Germans used to do. The earliest particulars of the Mexican game come from Lopez de Gomara, whose "Istoria de las Indias" was printed in 1552, so that it must have been written while the memory of the conquest in 1521 was still fresh. He says: "Sometimes Montezuma looked on as they played at *patoliztli*, which is much like the game of tables, and is played with beans marked with lines like one-faced dice, which they call *patolli*. These they take between both hands, and throw them on a mat or on the ground, where there are certain lines like a checker-board, on which they mark with stones the point which came up, taking off or putting on a little stone." This may be supplemented from three other old Spanish writers—Torquemada, Sahagun, and Duran. The figure on the mat is spoken of as "a painted cross full of squares like checkers," or as an "aspa," which word means a +, a Greek cross, the sails of a windmill, etc., descriptions which come as close as may be to the pachisi-board. Also, it appears that the stones moved on the board to mark the numbers thrown by the beans were of different colors, one account mentioning twelve stones, six red and six blue, between the two players.

According as the game was played, three to five beans were thrown as lots or dice, and sometimes these beans were marked on one side with a hole, and left plain on the other, while sometimes they seem to have had dots or lines indicating various numbers. If both ways were really used, then the game was known in both its stages, that of two-faced lots and that of numbered dice, just as in India it is played as

pachisi with cowries, and as chûpur with stick-dice. As to the way of scoring the throws, only one of the old writers says anything. This is Diego Duran, an extract from whose MS. history I have obtained by the courtesy of Mr. Oak, of the Bancroft Library at San Francisco. He says, as to the holes in the beans which showed how many squares were to be gained, that they were "if one, one, and if two, two, and if three, three, but marking five they were ten, and if ten, twenty." Thus in Mexico we just catch sight of the peculiar trick of scoring, everywhere so characteristic of the game, namely, the advantage given to the extreme throws, which in our own backgammon takes the form of allowing doubles to count twice over. Unluckily, the thought had never crossed the minds of these early Spanish historians of the New World that their descriptions of the Aztec game would ever become evidence of use in tracing the lines along which civilization spread over the earth. Had they seen this they would have left us a perfect set of rules, not such careless mentions of a game which plainly they "did not understand." Still they saw enough of Montezuma's patolli to observe that it was in principle like their own game of tables, while clearly they had never heard of the Indian pachisi, or they would have seen how much closer its resemblance came to that. This touches a point in the history of the game. How did the Mexicans get it? The idea may have already occurred to some readers of this essay, Could not perhaps some stray Portuguese or Spaniard, having lately picked up the game of pachisi in some seaport of the East Indies, have taken his next voyage to the West Indies, and naturalized his newly-learned game on the mainland of America? But there is no room for a suggestion of this sort when it is remembered that patolli was an established diversion in Mexico at the time of the Spanish entry, which followed within three years of the first landing of Grijalva in the gulf of Mexico, and indeed within five-and-twenty years of Colon's first sight of Hispaniola. What seems most likely is, that the game came direct from Asia to America, reaching Mexico from the Pacific coast.

That the remarkable civilization of Mexico as the Spaniards found it was not entirely of native American growth, but had taken up ideas from Asia, is no new opinion. Alexander von Humboldt argued years ago that the Mexicans did and believed things which were at once so fanciful and so like the fancies of Asiatics that there must have been communication. Would two nations, he asks in effect, have taken independently to forming calendars of days and years by repeating and combining cycles of animals such as tiger, dog, ape, hare; would they have developed independently similar astrological fancies about these signs governing the periods they began, and being influential each over a particular limb or organ of men's bodies, would they, again, have evolved separately out of their consciousness the myth of the world and its inhabitants having at the end of several successive periods been destroyed by elemental catastrophes? In spite of Humboldt we often

hear Mexican culture talked of as self-produced, with its bronze and gold work, its elaborate architecture and sculpture, its monastic and priestly institutions, its complicated religious rites and formulas. It was my fortune years ago to travel in Mexico and explore its wonderful ruins, and ever since I have held to the view that the higher art and life of the whole Central American district is most rationally accounted for by a carrying across of culture from Asia. Thus it is now a peculiar pleasure to me to supplement Humboldt's group of arguments with a new one which goes on all-fours with them. It may very well have been the same agency which transported to Mexico the art of bronze-making, the computation of time by periods of dogs and apes, the casting of nativities, and the playing of backgammon. What that agency was one can as yet do no more than guess, but too much stress must not be laid on it in speculating on the mass migrations of the American races. Such matters as arts or games are easily carried from country to country; nor can we treat as inaccessible to Asiatic influences the Pacific coast of North America, where disabled junks brought across by the ocean current are from time to time drifted ashore, now and then with their crews alive. The Asiatic communication to be traced in the culture of the Aztec nation may not have been very ancient or extensive; all we can argue is, that communication of some sort there was.

Now one thing leads to another, especially in ethnology. Curiously enough, by following up the traces of this trivial little game, we get an unexpected glimpse into the history of the ruder North American tribes. Having learned about patolli as played in old Mexico, let us take up the account of a Jesuit missionary, Father Joseph Ochs, who was in Spanish America in 1754–'68, and who is here writing about the tribes of Sonora and Chihuahua: "Instead of our cards they have slips of reed or bits of wood a thumb wide and near a span long, on which, as on a tally, different strokes are cut and stained black. These they hold fast in the hand, lift them up as high as they can, and let them drop on the ground. Whichever then has most strokes or eyes for him wins the stake. This game is as bad as the notorious hazard. They call it *patole*. As it is forbidden on pain of blows, they choose for it a place in the bush; but the clatter of these bits of wood has discovered me many a hidden gamester. To play more safely, they would spread a cloak or carpet so as not to be betrayed by the noise." Here, then, is found, toward a thousand miles northwest of the city of Mexico, a game which may be described as patolli without the counters, and which still bears the Aztec name, in a district whose language is not Aztec, so that the proof of its having traveled from Mexico seems complete. The people, being less intellectual than the old Mexicans, have dropped the skillful part of the game and are content with the mere dicing. Nor, by the way, is this the only place where backgammon has so come down, for in Egypt they will lay aside the board and throw the tâb-sticks for fun, those who throw four and six being proclaimed Sultan and Vizier,

while the luckless thrower of two gets for his reward two cuts with the palm-stick on the soles of his feet.

Yet another fifteen hundred miles or more up into the continent the game is still to be traced. Among the hunting tribes known under the common name of the North American Indians, there is a favorite sport described by a score of writers under the name of "game of the bowl," or "game of plum-stones." The lots used are a number of plum-stones burned on one side to blacken them, or any similar double-convex pieces of wood, horn, etc. They are either thrown by hand or shaken in a bowl or dish, whence they can be neatly jerked up and let fall on the blanket spread to play on. The counting depends upon how many come up of either color, white or black, as is seen in the precise rules given by Mr. Morgan in his "League of the Iroquois." Where six "peach-stones" were thrown, if all six came up, white or black, they counted five, and five up, white or black, counted one, these high throws also giving the player a new turn, but all lower throws counted nothing and passed the lead. It is so curious to find the principle of lot-scoring, which we have tracked all across from Egypt, cropping up so perfectly among the Iroquois, that at the risk of being tedious it is worth while to give in full the mode of counting in the game as played with eight "deer-buttons." The following top line shows how many black or white sides up, with their count below:

Eight	Seven	Six	Five	Four	Three	Two	One	None
20	4	2	0	0	0	2	4	20
go on			stop			go on		

In these games there is no board to play on. The Iroquois use beans as counters, the game being won by one player getting all the beans, but perhaps the white men taught them how to do this. So with the game which will occur to English readers who remember it in "Hiawatha," where it is described at full length in prose-poetry as "the game of bowl and counters, *pugasaing* with thirteen pieces." This game is real enough; indeed, the description of it is taken from Schoolcraft's "Indian Tribes." But there seem to be no early mentions of this Algonquin game with its ducks and war-clubs and elaborate counting, nor of the Dakota game with tortoises and war-eagle son the plum-stones. Thus both may have been lately devised by Indians under European teaching, as improvements on the original *pugăsaing* or "play," which was the simple game with black- and white-sided plum-stones, or the like. This, no doubt, is old, for it is described by the Jesuit missionaries in 1636 under the name of *jeu de plat*, as a regular sport among the Hurons; and as they clearly did not learn the game from Europe, we are left to argue that it reached them from Asia, very likely through Mexico.

It remains to glance at what may be learned as to the history of the North American Indians from the fact of their gambling with the bowl

and plum-stones. It is an interesting question whether "the poor Indian, whose untutored mind" has now and then been too easily credited with the invention of all the arts and beliefs he did not get from the white men, may not really before this have largely taken up in his culture ideas of Old-World growth. It has long been noticed that, looking at the native tribes of what is now the United States and the Dominion of Canada, the tribes on the east side had taken to making pottery and cultivating maize, while the tribes on the west had not, which seems as though there had been a flow or drift of civilization from the Central American district up the eastern half of the continent, which of itself ought to be enough to prevent any ethnologists from looking at the so-called red-man of New England or the Lakes as the creator of his whole industrial and social life. Nor is it an unknown thing that the myth and religion of the North American tribes contain many fancies well known to Asia, which the men of the prairies were hardly likely to have hit upon independently, but which they certainly did not learn from the white men, who did not even know them. If we are bound, as I think we are, to open a theoretical road for even a well-marked game to migrate by from Asia into America, then there are plenty of other matters waiting for passage along the route. By such conveyance of ideas it may be easiest to explain why the so-called Indians of North America shared with the real Indians of India the quaint belief that the world is a monstrous tortoise floating on the waters, or why the Sioux Indians share with the Tartars the idea that it is sinful to chop or poke with a sharp instrument the burning logs on the fire. But these considerations lead too far into the deepest-lying problems of the connection and intercourse of nations to be here pursued further. It is remarkable, too, how vast a geographical range the argument on the migrations of a game may cover. The American farmer now whiles away the winter evening in his farmhouse parlor with a hit at backgammon, on the spot where, not long since, the Iroquois played peach-stones in his bark hut. Neither would have recognized the other's sport as akin to his own, though when we trace them through the intermediate stages they are seen to be both birds of one nest. It is by strangely different routes that they have at last come together from their Asiatic home—one perhaps eastward through Asia, across the Pacific, into Mexico, and northward to the St. Lawrence; the other, no doubt, westward down to the Mediterranean, up northward to England, over the Atlantic, and so out into the American prairie.[1]—*Macmillan's Magazine.*

[1] For special details, copies of original documents, etc., see a paper by the author "On the Game of Patolli in Ancient Mexico, and its probably Asiatic Origin," read before the Anthropological Institute on April 9, 1878.

MITES, TICKS, AND OTHER ACARI.

By E. R. LELAND.

THE acari constitute a large order of minute animals, including mites, ticks, itch insects, etc., with which, in some of their forms, every one is more or less familiar, though, owing to their small size and obscure ways of living, but little is known of their structure and habits. They are often spoken of as insects, but are by scientific classification separated from the true insects, the most marked distinction being the possession of eight legs instead of six. Usually they are furnished with a suctorial apparatus. They are parasitic on both the animal and vegetable kingdoms. No class of animals is free from them. They prey upon each other; insects are infested with and support them at the cost of their lives; they attach themselves to fish and cold-blooded reptiles, and colonize on the whole range of birds and mammals. Some live under the skin, burrowing in the muscles; others dig corridors beneath the epidermis; while others, again, wander only on the surface. They are found in the lungs, air-passages, and intestinal canals of vertebrates. They are very prolific, and, though small, awkward, and slow-moving, they are transferred in a surprising way, often suddenly appearing about houses in enormous numbers, infesting plants and domesticated animals, or swarming on articles of food. Sometimes, especially in the tropics, they inflict considerable suffering; but it is probable that, on the whole, they are beneficial to man. A few directly injure him, and none directly benefit him, but indirectly they do him service by preying, as will be seen, on insect-pests and by acting as scavengers. The number of species in this family is so great as to forbid any detailed description, or even the merest mention of all of them. For the most part they are seldom seen except by those who make them a study. But a brief account of what is known about those of them that come into relations with man closely enough to affect his comfort and welfare, may be of interest and value.

The species thus referred to are found in the following classes: 1. Spinning and harvest mites, red spiders, etc. (*Trombidiinæ*); 2. Insect mite-parasites, sometimes called ticks (*Gamasidæ*); 3. True ticks (*Ixodidæ*); 4. Cheese and sugar mites, itch mites, etc. (*Acaridæ*)—the portion of the family commonly included under the name acari.

The spinning mites, like their relatives the spiders, can spin webs. They are of small size and semi-transparent. The most common is the red mite (Fig. 1), *Tetranychus telarius*, so well known to all who have the care of house plants. It is one twentieth of an inch long, yellowish, with two red spots on the sides, though its color

varies with the plant on which it is found, and in different individuals on the same plant; a rusty color shows maturity. This mite, like most of the genus, spins a web on the back of the leaves so delicate that a single strand can not be seen even with the aid of a common magnifier. When the web-work is done, however, it is plainly visible,

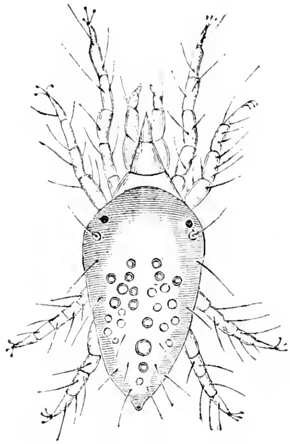


FIG. 1.—TETRANYCHUS TELARIUS—perfect insect, male.

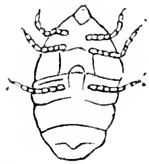


FIG 2.—TROMBIDIUM PARASITICUM.

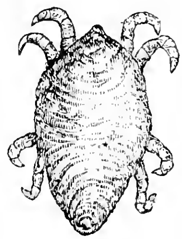


FIG. 3.—TROMBIDIUM SERICEUM.

and under it the mites congregate in numbers, and feed and multiply very fast. The leaves soon look sickly, are marbled with gray and yellow above, the underside being white and shiny, with recurved edges. A microscope will show hundreds of mites of all ages, together with unhatched eggs pasted to the web; they are draining the leaf-vessels of their sap, and choking the breathing-pores with excrement. The remedies used to get rid of them are various, but sulphur seems the most potent of them all. It is recommended to lay flowers of sulphur on the heating-pipes in the hot-house, or it may be mixed with soapsuds, and applied to the leaves. Plain soap and water is effectual if made to reach the insect, but a bent syringe or some other means must be employed to reach the underside of the leaves, otherwise the mites will remain in comfort and safety through a hard drenching. Luckily for the florist, they are preyed upon by other mites and insects—the grub or larvæ devouring whole colonies of them very quickly. The cucumber, cacti, vine, etc., as well as the shrubs and herbage of wood and field, support various species of this genus; they are all of similar habits while confined to vegetation, and to be got rid of by similar methods. But some of them transfer themselves to the skin with seeming ease, and when thus lodged cause great discomfort, producing itching and redness, and sometimes eruptions similar to those of the itch. Two species known in the Mississippi Valley as jiggers are very annoying to those who have to expose themselves where they

abound. Prof. Riley names and describes them as follows: *T. Americanus*, a mite barely visible to the naked eye, moves readily, and is found more frequently upon children than upon adults. It lives mostly upon the scalp and under the armpits, but is frequently found on other parts of the body. It does not bury itself in the flesh, but works its head under the skin, causing irritation, followed by a red pimple. *T. irritans*, the best known and most troublesome of the two, causes intense irritation and swelling on all parts of the body, but more especially upon the legs and around the ankles. By the aid of its strong jaws, the lower pair of which are elbowed, it buries itself completely in the flesh, resulting in a red swelling, with a pustule containing watery matter. If the mite be not removed the irritation lasts several days, the pustule refilling as often as it is broken. It is seldom noticed, being so small, and the uninitiated are often alarmed at the symptoms. Saleratus water or salt water will allay the irritation, but sulphur ointment effects a speedy cure.

Another red mite, belonging to a different genus, makes itself useful by preying on insects. One species, *Trombidium parasiticum* (Fig. 2), is found on the house-fly, which in some seasons is so infested that hardly one can be caught that is not loaded with mites clinging to the base of its wings. This or closely related species are found on spiders and mosquitoes, which they help to kill off. One species Dr. Packard found doing good work in eating the plant-lice off his rose-bushes; another attack the Rocky Mountain locust, the grasshopper scourge of the West; they attach themselves to the body under the wings, and suck it to a dry shell; while still another species, *T. sericeum* (Fig. 3), creep in great numbers into the holes where the locusts' eggs are and eat them.

The *Gamasidæ* are for the most part parasitic on insects, as the beetle, humblebee, wasp, etc., though the kinds here noticed are found on warm-blooded animals. They are sometimes called ticks, and are closely allied to that family. The mite shown in Fig. 4, *Dermanyssus avium*, infests domestic poultry, canaries, and other cage-birds, living in henneries and aviaries, and ready, like many of its congeners, to migrate to persons the first opportunity. They are small, white, and quite agile. A case is related in which these mites settled upon the skin of a woman otherwise healthy. She was constantly infested with little, louse-like animals, which were supposed to be bred on her body, as the greatest cleanliness failed to extirpate them. It was at last found that she went several times a day into a cellar over which the hen-roost was located. As often as she passed the fowls flew up to their roosts, and by this means sprinkled the woman with mites. The removal of the hen-roosts cured her. Fowls, when allowed to roost in stables, sometimes convey these mites to horses, torturing the poor brutes nearly to death, the owner being unable to decide what malady afflicts them. The mite is easiest ob-

served in the cages of singing birds. That they feed upon the bird is shown by their digestive organs being full of blood. They harbor in the recesses of the cage and the perches, particularly those made of hollow cane, and sally out at night to settle on the sleeping bird.

Fig. 4.—Dermanyssus avium.

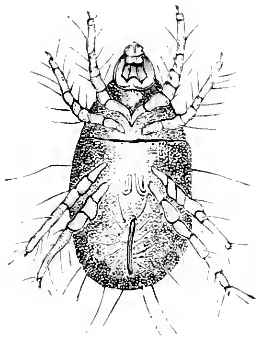


Fig. 5.—Tyroglyphus siro.

Scrupulous cleanliness should be exercised to prevent and remove them. Several members of this family are parasitic on cats. One species is found on dead bodies. A case has been cited where one was observed on the brain of a dead soldier, which had just been opened. Although the observer thought that the mite had been domiciled there, and upon the strength of this case the statement is often made that they are sometimes found in the brain, it is probable that the mite was in some way conveyed to the brain after it had been opened.

The *Ixodes*, or true ticks, are known by the tough, leathery skin of their abdomen and legs, their fastening on warm-blooded animals, and sucking their blood, for which they have a special mouth-piece. The body of the female is capable of great distention as she gorges. Their habit is herbivorous at first, for it is from the herbage that they find their way to the creatures on which they fix. They mount to the summit of blades of grass, or tips of leaves, and, holding on by their forelegs only, stretch the other three pairs out so as to fasten on any animal that comes in their way. Once settled, they plunge their proboscides into the skin, and suck the blood until their flat bodies become of a globular form, varying from the size of a number-eight shot to that of a bean. The process of filling is slow, sometimes taking days. Little irritation is felt, but the proboscis is liable to be broken off and remain in the wound, when serious sores are formed. Care should be used in taking them off; a little tobacco-juice will generally make them let go. Dogs after running in the woods often bring home quantities of them, and they may come to be permanently located in the dog-kennels. The common cattle-tick of the West is very annoying to horned cattle. Various troublesome species abound in the

tropics, and these exotic tick-mites are not infrequently imported on plants, and in the moss and sphagnum which horticulturists use in packing their wares. The habits of this group are somewhat anomalous; at first they are unquestionably herbivorous, but they greedily avail themselves of every opportunity of sucking blood instead of sap. No special adaptation is needed for this, as the sucking-apparatus is suited to both the liquid blood and the juice of plants, and is similar to that of all suctorial insects, which some use on plants, some on animals, and some on both. Of the immense swarms of ticks, gnats, mosquitoes, bed-bugs, etc., the majority probably never taste animal food at all, although so greedy for it when it comes in their way.

The sub-family, *Acaridæ*, is divided into two sections: the cheese-mites and their allies, and the itch-mites with their relatives. The first section produces a number of vegetable-feeders; several species are found on the scales of some species of *Liliaceæ*, principally hyacinths, and on dahlia-roots, cyclamen, potatoes, mushrooms, etc.; these occasionally cause itching and irritation to those handling them. The smallest species of this group, *Tyroglyphus entomophagus*, is a pest too well known to entomologists, upon whose collections it preys. It lives chiefly in the inside of the insects which it attacks, gnawing the soft parts of their bodies, and destroying the ligaments which hold the articulations together, allowing them to fall apart.

Edible mushrooms, especially the cultivated sorts, are often attacked by a moist black rot, which, until lately, has been regarded as spontaneous. But it has been shown that it is caused, or at least aided, by a species of mite remarkable for fecundity. The activity of their agency in this decomposition is shown by the fact that mushrooms on which they have been placed become, in forty-eight hours, a black, putrescent mass, on which myriads of these creatures swarm; while other mushrooms subjected to the same conditions, except the inoculation, dry up, and take from eight days to a fortnight to decompose. The presence of mites in great numbers on some of the common articles of food is well known. These are chiefly the cheese-mites, which are characterized by a soft, smooth, fleshy, whitish body, with generally a single claw, surrounded by a vesicle or fine sucker, like a sieve. *T. siro* (Fig. 5) is the principal mite which commits ravages upon cheese, living upon all kinds when a little decayed, and especially the harder parts. They hibernate during winter, crowded in heaps in chinks and hollows in the cheese; but with warm weather their activity begins, and they gnaw away, reducing the cheese to powder. This powder is composed of excrement in little grayish balls, eggs, egg-shells, larvæ, cast skins, perfect mites, fragments of cheese, and numerous spores of microscopic fungi. A mite-tainted cheese is not objected to by epicures, and the creatures are sometimes introduced to give a premature ripeness; but, if left to work unchecked, they will spoil a cheese very soon.

Linnæus described a mite under the name of *Acarus dysenteriæ*, to the presence of which was ascribed a persistent dysentery that attacked one of his pupils, and some later authors have thought it may have been the cheese-mite, or some of its allies; but this is improbable. Cheese-mites are constantly eaten in great quantities, and, so far as can be judged, with perfect impunity; if they did cause mischief, numerous cases would have been noted and reported, whereas there are none recorded. A mite is also found in flour, sometimes in abundance; Hassell, however, says it is never present unless the flour is damaged. Assuming it to be a separate and distinctive species, it was described by Linnæus and named *A. farinæ*, and has been so figured and spoken of by naturalists down to the present time. But Mr. Andrew Murray, whose excellent hand-book on "Economic Entomology" is freely used in this article, asserts that the flour-mite and the milk-mite are not distinct species, but are identical with the cheese-mite. Not, he explains, that every species found on cheese or flour is this species—for both are doubtless infested with others—but that the old authors have made two or three species out of one. The cheese-mite has been met with in very old linseed-meal, and has been found on wounds that had been dressed with poultices made of linseed-meal. Of course, its presence under such circumstances must be mischievous. Another species which lives on cheese, *T. longior* (Fig. 6), is distinguished from the above by its more rapid movements, larger size, and longer and rounder body. Its habits and diet are much the same, though they are not found together.

It is the species most commonly met with in stores of cantharides, which are very subject to attacks of mites. This species, Mr. Murray says, gave rise about 1837 to a good deal of talk among scientific people, as having been supposed to be produced by electricity. There was at that time in the semi-scientific world a vague idea in favor of electricity being the source of many of the phenomena of life. The limits and extent of its power were, of course, even less known than at present, and all sorts of wild experiments were tried. One gentleman set up lines of electrical wires over portions of his estate, with a view of ascertaining whether the plants would not thrive better under what he supposed would be an increased flow of electricity. Others made similar experiments in different directions. One gentleman, Mr. Cross, tried to produce organic beings by the aid of electrical apparatus. His process was to operate on volcanic stone kept moist by a solution of silicate of potash and muriatic acid, constantly subjected to electricity. After carrying this on for some time, he was rewarded by finding some of these mites wandering about his apparatus, and arrived at the conclusion that they had been produced by his electrical batteries. The species, therefore, enjoyed an ephemeral fame as a human creation. It was sent to M. Turpin, in Paris; having but a single dead specimen to work from, he believed it to be a new species,

but by no means endorsed the idea that it was created by Mr. Cross or his electrical apparatus. It was not only a highly organized animal, and nearly allied to a well-known species, but it proved to be a female, containing eggs, which, as he dryly remarked, seemed an unnecessary complication in a new creation.

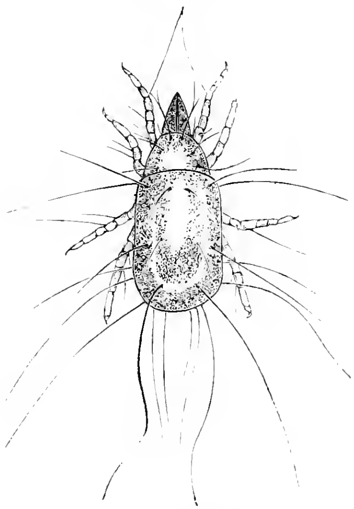


Fig. 6.—Tyroglyphus longior.

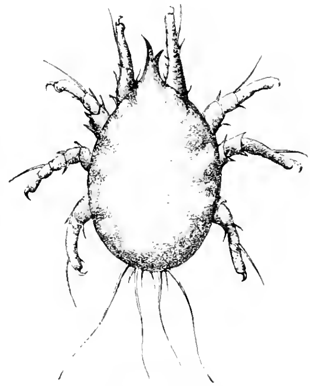


Fig. 7.—Sugar-Mite (*Tyroglyphus sacchari*).

The sugar-mite, *T. sacchari* (Fig. 7), is most commonly found in brown sugars. It is large enough to be seen with the naked eye, and sometimes appears as white specks in the sugar. It may be detected by dissolving two or three spoonfuls of sugar in warm water, and allowing the solution to stand for an hour or so; at the end of the time the acari will be found floating on the surface, adhering to the sides of the glass, and lying mixed with the grit and dirt that always accumulate at the bottom. In ten grains of sugar as many as 500 mites have been found, which is at the rate of 350,000 to the pound. Those who are engaged in handling raw sugars are subject to an eruption known as "grocers' itch," which is doubtless to be traced to the presence of these mites. They are almost invariably present in unrefined sugars, and may be seen in all stages of growth and in every condition, alive and dead, entire or broken in fragments. Refined sugars are free from them; this is in part due, perhaps, to the crystals being so hard as to resist their jaws, but principally to the absence of albumen, for without nitrogenous matter they can not live. The sugar-mite is also found on the surface of jellies and preserves that have begun to dry, and on the sugar of dried fruit, such as figs, prunes, cherries, etc. They sometimes accumulate in the mouth of wooden taps used for wine and beer. In dismissing this part of the subject, which refers to mites infesting food, it seems proper to say that the

common assertion that living forms are a matter of course in everything that we eat and drink is without warrant. While it is true that water and one or two other articles usually contain microscopic organisms, the idea commonly conveyed by such statements is erroneous. These degraded and disgusting forms are not proper food-stuff; nor is their consumption unavoidable. Pure articles, in an undamaged condition, do not contain them; and their presence in numbers in any article of food is proof that it is unfit for human use, and should be rejected.

There are several species, placed by later authors in the same genus with the sugar-mites, whose normal habitat seems to be on food, insect collections, and in the dust and mold of cellars and damp places, but which, when transferred to animal bodies, become parasitic, causing curious and painful disorders. Signor Moriggia figures a singular horny excrescence which grew from the hand of a lady. It was nearly eight inches long, tapering upward from a wide base, and curved toward the wrist. Its cavities were swarming with a species of acari. Another species was found by Hering in the hind feet of a horse, that, although young and in other respects sound, had to be killed. The hoofs were quite disorganized, the frog and sole consisting of a soft, fibrous mass, secreting an offensive liquid; in the end, the sore spread to the flexors and muscles of the fetlock. A negro inmate of the Seaman's Hospital, London, suffered from large and peculiar sores on the soles of the feet. Examination by Prof. Busk revealed the presence of a mite, which was doubtless the cause of the trouble. The negro attributed the disease to wearing a pair of shoes which were lent for a few days to another negro who was similarly afflicted. The latter came from Sierra Leone, and inquiry proved the existence of a pustular disease, native to that place, called *craw-craw*, a species of itch very troublesome to cure.

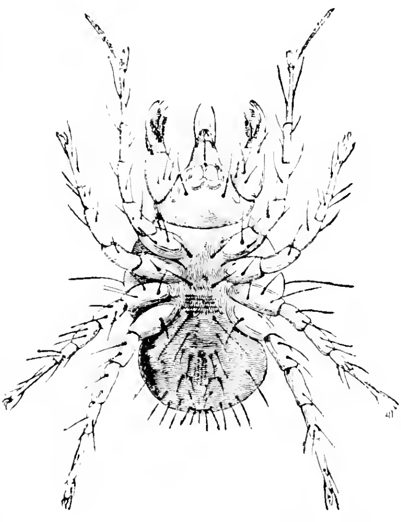


Fig. 8.—Cheyletus eruditus.

The genus *Cheyletus* is a very remarkable type. It is unquestionably carnivorous, its palpi being adapted for holding its prey. They are not gregarious in their habits; but, like all animals that live by rapine, are solitary. When placed in company with the cheese-mites, they seize them between their palpi, and, plunging their beaks into the body, suck up the juices. The *C. eruditus* (Fig. 8) appears also

to have poisoning powers similar to those of the spider. They seize their victim by the leg or any other part, who, after the lapse of fifteen or twenty seconds, becomes paralyzed, makes no resistance to the devourer, and remains passive till nothing is left but an empty and shrunken shell. The poison has no effect on its own species: they frequently feed on each other; but in that case the prey struggles so long as any fluid seems to be left in the body. It is found in the dust of hay, old grain, meal, and flour, on collections, and also on books, from which latter it derives its name; but, in the opinion of Mr. Murray, it is so found because other gregarious acari congregate there, and "we should no more think that it was there for the purpose of feeding on those stuffs in which it is found than we should admit that a cat eats hay because it is found in a rat-infested hay-stack."

The occurrence of the phenomena of parthenogenesis among acarids has been shown by this species. Mr. Beck succeeded in rearing three successive generations from a female without any intervention of the male. The female is very careful of her eggs: she lays them in a heap, and rests brooding over them, guarding them from attack.

The itch-mites, *Sarcoptes*, infest the larger mammals. The commonest species, *S. scabiei*, which preys on man, when seen with the naked eye, looks like a white, shining globe, or a little bladder of

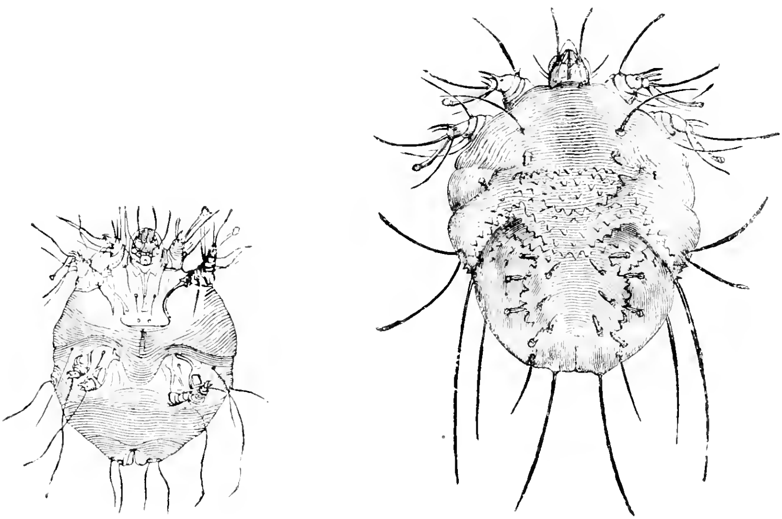


Fig. 9.

Sarcoptes scabiei—Male. Sarcoptes scabiei—Female.

water, $\frac{1}{75}$ of an inch long and $\frac{1}{100}$ of an inch wide. The microscope brings to view (Fig. 9) a round, flat body, with a head not unlike that of a tortoise, provided with powerful jaws and nippers, the structure of which is well adapted to mining the skin. The body is set with

strong, short legs, terminating in long spines (Figs. 10 and 11). The feet and nippers are provided with suckers. They have no eyes; but, with their habits of life, the absence of these organs causes them no inconvenience. The impregnated female digs a long burrow in the skin, depositing her eggs as she moves. If one of the early vesicles of the itch is examined, a small spot may be seen upon some point of the surface; this is the opening made by the mite to begin its tunnel; leading from this, a white, fluted line may be traced, which is the cuniculus or burrow of the acarus, and the fluted or dotted appearance is due to the eggs, the white dots showing where they lie (Fig. 12).

FIG. 10.—Two of the Posterior Legs of the Male *Sarcoptes scabiei.*

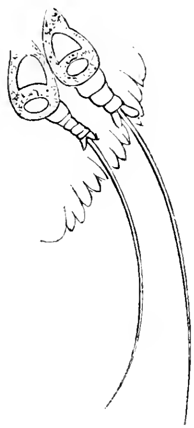


FIG. 11.—Two of the Posterior Legs of the Female *Sarcoptes scabiei.*

The burrow varies in length, sometimes reaching half an inch, and at its end, under a slight elevation, lies the mite. The cut shows a burrow with a number of empty shells scattered along the line, with one unhatched egg close to the mite. Close inspection will reveal a small, dark point at the end of the burrow; and, if the skin be raised there with the point of a needle, the creature can be brought to view and easily extracted. The itch-mite is never found in a vesicle or pustule; indeed, there is no connection between the later vesicles and the burrow; they are evidently caused by the proximity of the mite. The larvæ and young females hide themselves in broken surfaces, or burrow a short distance into the skin; the male retreats under any protecting edge. The advance of civilization, with its increased use of soap and water, has done much toward exterminating this pest; the "Jackson itch" and "seven-year itch" are much less heard of than formerly; but wherever, as in army life, men are crowded together, and personal cleanliness is neglected, it reappears in a most flourishing condition. The disease must, of course, be conveyed by transference of the mite from those who are infected to those who are sound;

but the mode of transmission has been a puzzle, it being observed that among doctors and hospital attendants infection was comparatively rare. This is explained by the nocturnal habits of the mite—or, if not truly nocturnal, its activity is promoted by a certain degree of warmth, so that it lies dormant during the day, when the body is cool, to sally forth in search of new fields when stimulated by the genial warmth of the bed. This explains also why the itching is most violent at night. The mode of getting rid of the parasite is obvious; we have only to kill it; and, fortunately, the means is cheap, easily applied, and perfectly effectual: sulphur, which seems to be a deadly bane to all insects, in whatever shape it can be given. It is only necessary to expose the insect to its influence, and it surely dies.

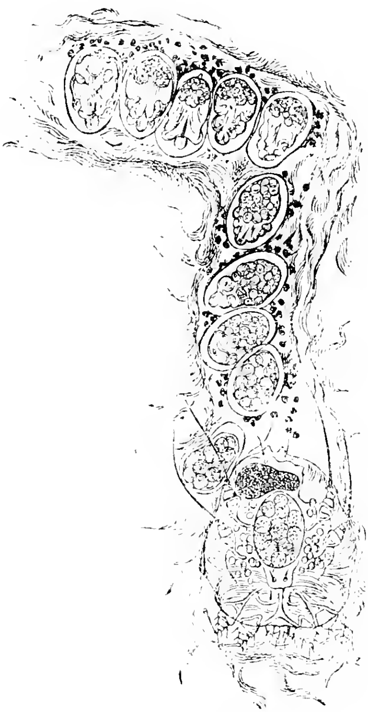


Fig. 12.—Burrow of Itch-Insect (*Sarcoptes scabiei*).—Female depositing eggs. The eggs lying next to the insect consist partly of an homogeneous, partly of a granular mass; in those distant from the insect embryos are already developed, and at the entrance of the furrow a moving acarus is seen.

One curious point regarding these mites is, how they produce the physiological effects that characterize their attacks. Their incessant gnawings and nibblings are undoubtedly sufficient to cause great irritation; but there are the different symptoms induced by different species—scurfy, inflamed surfaces, coarse, leprous crusts, deep ulcers, etc.; can these be accounted for by degrees of mechanical irritation, or are they possibly the result of some special poisonous virus? The itch-mite is found on the lion, dog, sheep, ox, horse, pig, and other animals, as well as on man. There are several other species, as the *S. scabiei-crustosæ*, or Norwegian itch-mite, most common in Norway, but not wholly confined to that country. The mite is much like the common species, but smaller and darker. The malady is similar to that of the common itch, though all the symptoms are intensified, the tubercles and crusts growing enormously. It yields, however, to cleanliness and the sulphur treatment. *S. cati* infests the domestic cat, the points of attack being the base of the nose, the lips, the ears, and the eyes, but spreading in all directions; the animal is reduced to a pitiable condition, being literally devoured alive by the parasites, if not de-

stroyed before this extreme stage is reached. This complaint is chiefly seen in great towns. *S. mutans* (Fig. 13) is parasitic on birds and domestic fowls, appearing on the feet, on the comb, and about the beak, gradually spreading until the whole body is involved. Other species have been found on other domesticated and wild animals, while a large genus —the louse-mites, *Myobia*—infest the smaller mammals, as rats, mice, cats, etc.

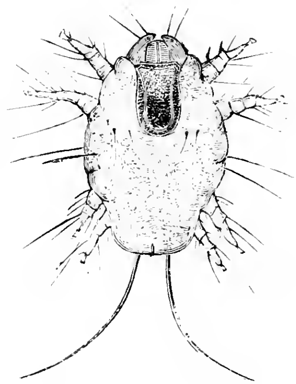


Fig. 13.—Sarcoptes mutans—Male, under-side.

The *Demodex folliculorum* is a minute animal, $\frac{1}{100}$ to $\frac{1}{50}$ of an inch in length, that lives in sebaceous sacs and hair follicles of the human skin, particularly about the nose (Fig. 14). Its habits are in some respects similar to those of the itch-mites. It is not a normal inhabitant of the follicles or glands, but appears to enter them from without. If pressure be made upon any one of the sebaceous follicles that are enlarged and whitish, with a terminal black spot, matter will be forced out, consisting mostly of accumulated sebaceous secretions, in which the parasite, if present, will be imbedded together with its eggs and young. The secretion may be softened with oil, so that these may be separated and the animal removed with a pointed brush. They do not seem to be present in all persons, occurring in two or three cases out of ten, and seeming to prefer thick, greasy skins. They are entirely harmless, and their presence is no indication of disease. The family roll of the acari closes with the gall-mites, *Phytoptidæ*, a curious and little-known group that causes the abnormal growths known as galls on the leaves and other parts of various plants. Any extended reference to them here would be out of place. The whole of the order *Acarina* afford interesting objects of investigation, being in close relations to man, and yet very imperfectly known. Some of their forms are always attainable, and an examination of them under the lower powers of the microscope is one of the most amusing objects of study that can be presented to the young.

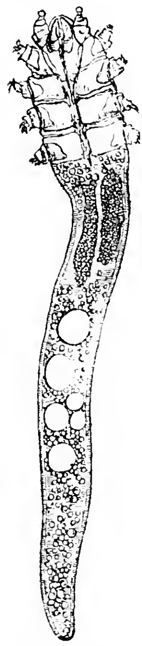


Fig. 14.—Demodex folliculorum.

TYPHOID-FEVER POISON.

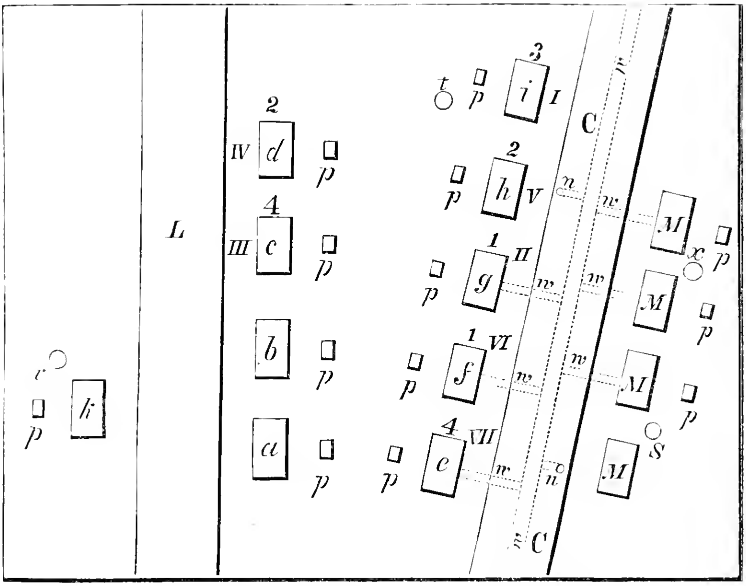
By ELY VAN DE WARKER, M. D.

On the 4th of September, 1876, Otto Schmidt, an industrious and thrifty German, reached his home after an absence of a week at the Centennial Fair at Philadelphia. How and where he lodged, and what he ate, during the five days he was at that city, we have no means of knowing, for, by the time he had exhausted the marvels of the exhibition in his voluble German tongue, he had lost all idea of unity of place, and was wandering mentally amid the busy wonders of Machinery Hall. The reason of his mental migration was a very simple matter. Otto was sick. On the 8th he complained of headache, bodily prostration, and mental lassitude. The next day the distress in his head was very severe, with pain in the back and limbs, and chilly sensations. The day following there was fever with loss of appetite, and toward evening he vomited the only food he had taken that day. On the 11th he thought he was better; but on the 12th the fever, both morning and evening, was marked. The next day he was seen by a physician, and the disease was recognized as typhoid fever. And here, having given in brief the history of the misfortune that had befallen Otto, let me describe the little segment of the world that held all that was dear to him in the way of family and friends. In order to appreciate what follows, every point and detail in this miniature survey must be understood and remembered.

No reader of history can follow the marching and countermarching of hostile armies without his map; and here also, upon a space of ground one hundred and sixty-five by five hundred feet, we have the invasion of an active, subtile, invisible foe after due declaration of war. To the reader and myself this narrow limit of ground is historical. Here was fought one of the most destructive battles ever recorded in the annals of human misery—a campaign between this imponderable invader and the vitality of a score of human beings. This conflict was waged unheeded by the dense population around, which seemed bent more on enjoying itself during the pleasant harvest weather than witnessing an unequal fight.

The —— ward of the city of Syracuse is built in its northern extension upon a series of parallel hills and valleys. These hills, with steep eastern and western flanks, govern in a measure the direction of the streets. There are three of these crests, with corresponding valleys. The locality indicated in the cut is situated in the central depression. Directly to the west it is commanded by the second ridge, the sides partly built up, partly terraced, and the summit is crowned by Lookout Park, a pleasure-ground of doubtful promise, its scanty verdure being checked in its growth by the stony soil and the violent winds that

sweep the summit. The slope of the hill east of the infected locality is of much lighter grade than that of the western ridges, and is thickly built up with small frame houses, except that about one hundred yards south of the group of houses, shown in the cut, the slope of the ridge is covered to the extent of twelve acres by the city cemetery, filled by



EXPLANATION.—*a, b, c, d, e, f, g, h, i, k*, houses; *L* and *C*, streets; *w, w*, sewer and house drains; *p*, privies; *s, t, u, v*, wells. The Arabic numerals attached to the houses indicate the number of cases of fever in each. The Roman numerals indicate the order in which each house was invaded by the fever. *n*, sewer opening in the street gutter. *M*, uninfected houses.

eight thousand interments, and still used as a burying-ground. This second valley differs from the other in being gradually narrowed in its northern extension, so that the streets *L* and *C* gradually approach and enter each other at an acute angle about one hundred yards north of the scene of the infection. The little group of houses shown in the map are isolated by vacant lots to the north and south. The houses were one story frame, gable ends faced to the street, neat and comfortable, and were, with one or two exceptions, little freeholds, occupied by their owners, tidy and industrious Germans, except that the houses *f* and *g* were occupied, one by English and the other by Irish-American families. The houses were built two upon each city lot of sixty-six feet front by one hundred and twenty feet deep, and separated from each other by light picket and board fences. Several of the owners turned their ground to account by growing vegetables. At an average distance of twenty feet to the rear of each house were the usual privy-vaults, all of them too shallow and badly cared for. The water-supply

was very defective, as this portion of the city was not supplied by the city water company. Well-water was therefore used for drinking and cooking purposes; while for washing, rain-water was caught either in cisterns or hogsheads. The water for culinary use was obtained from three sources. The houses *g*, *h*, *i*, *c*, and *d* obtained water from the well *t*; the houses *a*, *b*, *k*, from the well *v*; while the people in houses *e* and *f* crossed the road and patronized the well at *s*. This was the customary manner of supplying their wants. The source of supply at *s* was cut off during a short time, but, as this incident gave a clew to one of the most interesting facts of the investigation, I shall consign it to a later period of the narrative for the sake of what the critics call the dramatic unities.

Assuming that the details of the locality are sufficiently clear to enable the reader to understand the different steps of the search, I shall give at once the marches and halts of the fever in its invasion, and the amount of damage it inflicted on the population of our intra-mural hamlet.

As the reader knows, Otto Schmidt was taken sick on the 8th of September, and, as we have given him all the importance that belonged to him individually, I shall designate the other cases by the letters indicating the different houses. On the 4th of October a young woman was taken sick in the house *g*, the only case in a family of four; six days later the first case occurred in *c*, a family specially afflicted, as here four persons were stricken, leaving but two of the family, girls aged ten and fourteen years, untouched. These four cases were taken sick in the following order—the 10th, 14th, and 23d of the month; on the 20th and 26th we have two other cases in the house *d*, and two cases, at intervals of eight and twelve days later, in the house *h*, near neighbors of the Schmidts. In the house *f*, at nearly the same time, a case of the fever occurred. The last family attacked resided at *e*, and here the disease seemed to linger with special animosity, the first person being attacked on October 28th, and the last on November 8th. At this place and date the disease expended its force. In Otto Schmidt's family there were two additional cases taken on the 16th and 20th of October. In the total there were seventeen cases; five were very light, what some authors have called "walking cases." In the remaining twelve cases there were three deaths, one from an intercurrent pneumonia, or lung inflammation, one from intestinal hæmorrhage, and the other, without any special complication, gave way before the onslaught of the poison.

In an investigation of the kind before us we must have a knowledge of all the circumstances, and therefore, even at the risk of weaving such a complicated array of events around this drama of disease that it may need the skill of a professional novelist to disentangle us from the meshes, we must glance for a moment at the condition of the weather during at least the early part of the outbreak. From about the begin-

ning of September a period of continuous dry weather characterized the month; there may have been one or two slight showers, but not sufficient to change the general condition of dryness of earth and air. During this drought the well at *s* gave out, and continued dry until replenished by the late fall rains. The wind, blowing generally from the west and northwest, served to keep the temperature down, but not to lessen the unpleasant dryness of the air. This was changed on the 20th by a thunderstorm from the west, repeating itself from the east after a brief interval with nearly equal force. So violent, however, were the wind and rainfall, that the water was carried off by surface-wash, filling up sewers and cellars and tearing out gutters, but doing harm rather than good to vegetation. The drought was ended, however, as this was followed by a series of easy showers. During October there was much wet and cold weather, the meteorological complexion of the late fall being decidedly unpleasant.

Now that we are ready to begin the story of our search, what shall we look for? We have here a circumscribed outbreak of typhoid fever, a disease admittedly of an infectious nature, but proceeding from what kind of infection? Shall we content ourselves with finding a heap of decomposing vegetable or animal matter, or rest satisfied by discovering an escape of sewer-gas from some untrapped drain into one or more of the houses? Since we—the reader and I—are scientific and reasonable people, we can not adopt the theory that the disease is contagious—an opinion held by some able but rather easy-going physicians—and having once effected a lodgment in the community is capable of infecting all who have systems favorable to the development of the poison. The disease is not contagious in the sense that small-pox and scarlet fever are. We have proof in the outbreak we are studying that it is not of such a nature; but we have further proof. Liebermeister says that he had never seen in the hospitals of Greifswald, Berlin, and Tübingen a single hospital patient, physician, or nurse attacked with typhoid fever, although such cases were placed in the general wards. Dr. Murchison states that during a period of fourteen years 2,506 patients were treated for typhoid fever in the London Fever Hospital, and yet during this long period, and notwithstanding this vast number of patients, only eight cases originated in the hospital. It is needless to cite further evidence, and, since we can not save ourselves hard work by the slipshod theory of contagion, we must explore further.

Sewer-gas and decomposing matter we can not dismiss in this summary way; for here we are entering upon the special preserves of boards of health, sanitary engineers, and all others who advocate the gospel of cleanliness. In admitting or excluding sewer-gas as an element in the spread of the disease, we need a more complete array of conditions than is furnished by our group of houses; but such evidence as is wanting we must procure from other sources. A glance at the cut will show that but three houses in the fever-group were connected

with the street sewer. Two of these, *e* and *f*, were drained from the cellars by cement pipes four inches in diameter, the slops from the houses being thrown upon the ground. The house *g* was drained both from the cellar and by a branch pipe, untrapped, leading to an open sink by the side of the kitchen door. Two of these houses were the sixth and seventh in the order of invasion by the fever. There can be but little doubt in the event of heavy rains and sudden change of temperature that sewer-gas escaped into these houses. I never was able to detect such an escape of gas, but I concede the fact from what I know of city sewerage. If, however, we accept the explanation of the propagation of the fever after its first introduction in the person of Otto Schmidt by means of the sewer-gas, we leave unexplained a very important circumstance. In the group of infected houses but three out of seven were connected with the street sewer, so that in this particular outbreak sewer emanations are not competent to explain the extension of the disease. We may throw yet further doubt on the sewer theory by the fact that in the cottages *M*, containing numerous inmates, we have a group of uninfected houses, three of which were directly connected with the same sewer. If we were seeking for the cause of typhoid fever in defective drainage we should select these uninfected houses, as they not only had untrapped sewer pipes in the kitchens, which were practically the living-rooms of the families, but they were built at the foot of the slope and received the surface-wash of the rich alluvium of the hill to the west. Notwithstanding these unhygienic conditions and the actual existence of seventeen cases of the disease on the other side of the street, we find here complete immunity. When we have considered what this fever-poison really is, we shall be in a position to understand the origin of the disease from this source.

In seeking for a cause of the rapid spread of the fever in decomposing matter we are still at fault. The houses were all new, none of them having been built longer than five years. About none of them was found anything like an accumulation of refuse matter. They were careless about disposing of the water from wash-tubs and what is familiar to every housewife under the name of "dish-water"; but these were disposed of with more care than usual, as owing to the dry weather they were scattered over the gardens. In the condition of the vaults a critical inspector could find fault, yet they were in as good condition as these very defective household appendages usually are. Admitting a focus of infection at the house of Otto Schmidt, it is difficult to conceive of such a wide diffusion of the virus as to suddenly establish a focus at each of these seven points. This, however, is one of the least of the difficulties met with in tracing the disease to the decomposition of animal or vegetable matter. In typhoid fever we have a specific disease; that is, it exhibits a well-defined and uniform manner of beginning, a culmination and decline equally well marked, and, taken together, a group of symptoms and anatomical lesions that define

typhoid fever and no other disease the world over, and under all conditions. The question comes up—and the pythogenic (putrefaction) theory must be competent to afford an answer, or it will have to be abandoned—In what way can an infection, which must be composed of many heterogeneous and opposing elements, and produced under widely different conditions, be capable of producing in different individuals, each affording a nidus for the development of the poison under an almost infinite diversity of circumstances, one uniform train of symptoms, one specific, well-marked disease? The answer to this is, that it depends on the kind of matter decomposed. To human excrement, above all others, has been given this fatal power. To this recently sewer-gas, which we have already excluded from the chain of possible causes, has been added. But typhoid fever has never been produced by experiments with decomposing substances, nor by products of decomposition accidentally introduced into the human body; and, further, it is opposed to our daily experience. There are vast numbers of houses in which the affluvia of vaults may be detected in all the rooms, others in which the inmates are constantly inhaling sewer-gas, and the fixed as well as the transient inhabitants escape the disease. It is safe to say that cities with defective sewerage are the rule; that some cities and villages are more filthy than others; that in some quarters of a city the decomposition of organic and excrementitious matter is constantly going on; and yet we find typhoid fever prevailing independently of all these theoretical sources of infection: we find it localized in one section, even in one block of buildings, while others presenting equally favorable conditions have not produced a case within the memory of man.

The theory has been seriously damaged by its friends. Not only typhoid fever, but a series of specific diseases, of the origin of which we are in a measure ignorant, have been referred to the decomposition of organic substances. Dysentery, yellow fever, cholera, typhus fever, and the plague have been assigned to this cause. Liebermeister says that this "very circumstance shows that to explain the origin of typhoid fever by a general and indefinite assumption of a decomposition of organic substances is not satisfactory. It is not every kind of decomposition that can produce typhoid fever; it must be some specific form of decomposition which elaborates as a specific product the poison of that disease."

In the epidemic which we are studying we have excluded the theory of contagiousness. We saw in the conditions reasons for excluding the sewers as a means of extension; and I trust, from what I have said of the nature of the disease-germs, the reader is willing to admit that I have some reason for the belief that we can not find an origin *de novo* in the house-vaults.

The atmosphere in this epidemic is not a probable means of the extension of the germs. We are not able to say positively that the

air will not convey the poison, although it is safe to say that the area of its diffusion by this means is very limited. Instances in which sewer-gas has been known to be the means of conveyance are numerous, but the cases were confined to one or more rooms directly communicating with the sewer, or to a limited part of a building. But the typhoid-fever poison is not a gas. In such a shape we can not conceive that it will lie dormant in suitable soil, that it will undergo phases which so closely resemble germination and growth, or that it can be transmitted to long distances when given a proper vehicle. We have here a right to make a scientific use of the imagination. We can not imagine it a gas, but we can form an idea of it as an atom, a germ capable of preservation, growth, and infinite multiplication. It has never been seen; it may be that it will never be seen. In the physical sciences we project ourselves ideally into the midst of many things unseen, yet with perfect theoretical conviction in the reality of their existence.

In the group of cottages to which the epidemic was confined we observe a certain order in the arrangement of the infected buildings. A close examination of the plan is nearly sufficient to convince one that this order is not due to chance. Nor can we explain it by a conveyance of the disease-germs in the clothing of the inmates. We have in the exempt houses a sufficient warrant against this supposition. The inhabitants of the exempt houses, as the outbreak of the fever extended, assumed generously nearly all the care of the afflicted families. They were daily and nightly in attendance upon the sick, and in many cases assisted in washing the linen. If this were true of the inhabitants of the houses that were exempt from the scourge, we are nearly safe in excluding personal conveyance of the germs by those who inhabited houses showing a sequence of infection.

During my attendance upon several of the cases I repeatedly looked over the ground and studied the habits of the different families, but, I am ready to confess, without discovering the clew to the extension of the disease from the single focus in the person of Schmidt; that is, to discover a clew that would meet the demands of the scientific germ theory. However, I became convinced that if I were able to find some domestic arrangement or prevailing condition that linked the infected families together under a common liability to the disease, I should become master of the position. Such a connecting link I found in the water-supply of the different families. I did not make the discovery accidentally, but only as a result of a systematic investigation. In all researches of this kind I believe that it is rare that the truth is stumbled upon in the course of a careless search. If we do not exclude cause after cause in the course of the search, we are almost sure in the end to halt midway between two probable conclusions without being sure of either.

It is necessary to recall the fact that five houses, *g*, *h*, *i*, *e*, and *d*, were supplied with water from the well *t*—an open curb-well, loosely

stoned up, belonging to Otto Schmidt. All of these houses were invaded by the fever. But it is necessary to account for the contamination of the water. Here comes in the fact that gave me the key to the mystery. On the 20th of September, as I have already stated, there occurred a severe thunderstorm. It was so violent that a large amount of the rainfall was carried off as surface-wash. It did considerable damage to the gardens, and, among other things, filled up to overflowing the vault attached to Otto Schmidt's house. Here was deposited all the excrementitious matter from this severe case of the disease. It was easy to observe, from the appearance of a board walk, of the grass and ground, that the overflow had scattered material of this kind in the neighborhood of the well. Whether it ran into the well, or filtered through the ground, it is difficult to say; either could have occurred, or possibly both.

Now observe what occurred. Fourteen days after the shower, the 4th of October, a case of the disease broke out in the house *g*. Twenty days after, the first case was taken down in the house *c*; thirty and thirty-six days later, two cases in *d*, and two cases at intervals of six and twelve days later in the house *h*. These were the families habitually dependent on the Schmidt well for their supply of water.

Admitting that I am right in tracing these cases to the contamination of the well *t*, by the shower of the 20th of September, we have left two families in which occurred five cases of the fever who did not make use of this well. On questioning the people in the houses *e* and *f*, I learned that they crossed the road and drew water from the well *s*. This missing link in my chain of cause and effect made a halt in my investigations. I had fancied that I was so near success that I took this disappointment as a sort of personal matter, and was half inclined to give the whole thing up. I made another effort; I crossed the road and investigated the well and its owner. There was no fault to be found with the well, which was a "drive well"; but the owner told me that it occasionally became dry, and was in that condition before and for a week or two after the great shower of September. Back I went to my fever-houses, and exploded this question like a bomb-shell in the midst of their inhabitants: "Where did you go for water when the Bogert well was dry?" "Oh, we went to Mr. Schmidt's well."

After this testimony let us trace the course of the invasion a step further. The fever appeared among the inmates of the house *f* on the 20th of October, and of the house *e* on the 28th. Had we no further evidence, here is sufficient to render probable that these cases were due to drinking the infected water from the Schmidt well. But we may strengthen it by negative evidence. The inhabitants of the uninfected group of houses on the opposite side of the street at *M* never used the suspected well. When the well *s* became dry they resorted to the well at *x*. There is one other group of uninfected houses, two of them belonging to the same block as the infected houses, and one situated on

the opposite side of the street L. These three houses contained fifteen inmates, all of them coming into frequent contact with the sick. These people were supplied with water from the well at v, and were throughout the epidemic exempt from the disease. Thus, to sum up, all the families that were supplied from the Schmidt well after the 20th of September had one or more members attacked by the fever; all the families that were furnished with water from other sources escaped. The conclusion is reasonable that in the drinking-water we have the means of the diffusion of the germs.

I have here shown a direct connection between the case of Otto Schmidt and that of every other infected person. This connection, traced through the drinking-water, was a discovery in our own epidemic; but it is by no means a discovery as a means of diffusion of the disease. This has long been known, and the literature of the subject is full of instruction.

It must be borne in mind, however, that not all water contaminated with organic impurities will cause typhoid fever. There must be among these impurities the specific poison of the disease. And this, as we have been able to prove, can be traced to former foci of typhoid fever. Other fluids may be contaminated in the same manner. An interesting report of an epidemic of the disease in England was given in the "Lancet" several years ago. A pasture had been manured by sewer products. Here were fed a large number of milch cows. In a neighboring town typhoid fever became rife. The victims, it was discovered, all used milk from this dairy; those who did not make use of it escaped. One can not help speculating about the way in which the disease-germs entered the milk. The more probable explanation is a mechanical one: that the germs adhered to the udders of the cows and were brushed off in the act of milking. It hardly seems reasonable that the germs passed through the organism of the cows and thus entered the milk. The theory of a *contagium vivum* is further fortified by the circumstance that, by boiling, the power to harm is taken away from the infected fluids.

It must be observed that between the entrance of the infecting elements into the system and the breaking out of the symptoms which define the disease, a varying period of time intervenes. This is called the period of incubation. It is a feature which distinguishes the entire group of infectious diseases. In determining the length of this period there are two elements of uncertainty: first, it is difficult to fix the exact time of infection; secondly, it is often impossible to define the exact beginning of the disease. In typhoid fever, especially, the onset is insidious and slow. Days and even weeks may be passed in a depressed, languid state of the health, before the disease is recognized as typhoid fever. Among business men these initial symptoms are often explained by taking cold, or by overwork. During the epidemic at Basle a few persons were attacked after a residence in the city of from seven to fourteen days; others after sixteen days. Haegler found in

three cases caused by drinking-water a period of incubation of twenty-one days. In our own epidemic one case occurred in fourteen days after drinking the water, the average time being about twenty days. The general experience at the present time points to an incubation of about three weeks; but it may vary from two to four weeks, or even longer.

It is an interesting question, but one to which I cannot give a satisfactory answer, Why do not all who are exposed to the infecting cause suffer from the disease? In some cases it may be due to idiosyncrasy. Some people resist powerfully the encroachment of all infectious diseases, while others seem fated to have an opportunity of testing in their own person every prevailing malady. Experience teaches, however, that typhoid fever, unlike many other diseases of the group, is favored in its development by unhygienic surroundings. Bad air, bad food, uncleanliness, and over-population of a house or quarter of a city, create a condition in the system favorable to a rapid and virulent development of the fever after an infection by the germs. We know, nevertheless, that no house nor person is exempt from the disease after receiving the exciting cause. Prince and peasant alike have to bow to the malignant potency of these infecting germs.

SKETCH OF ELISHA GRAY.

By GEORGE B. PRESCOTT.

ELISHA GRAY, the inventor of the Speaking Telephone, was born at Barnesville, Belmont County, Ohio, August 2, 1835. During his boyhood he was profoundly interested in all the phenomena of nature, and had an intense desire, whenever he saw any manifestation of physical force, to become acquainted with the secret of its operation. Among all the phenomena throughout the domain of physics, nothing took such hold upon his mind as that exhibited in the various effects produced by the action of electricity, and he read whatever he could find relating to this subject with the same eagerness and interest that most boys would read "Robinson Crusoe" or the "Arabian Nights."

While yet a boy he constructed a Morse register, all the parts of which were made of wood, with the exception of the magnet, armature, and embossing point in the end of the lever (which latter he made by filing a nail down to a point). He had the magnet bent into a U-form by a blacksmith, and then wound it with brass bell-wire, which was insulated with strips of cotton cloth wrapped around it by hand. For a battery he made use of a candy-jar, in which he placed coils of sheet copper and zinc, with a solution of blue vitriol. With these materials he succeeded in making a very good electro-magnet, which would sus-

tain nearly a pound weight, and which, when mounted as a part of the instrument, performed the work of actuating the armature with perfect success.

At quite an early age he was apprenticed to a blacksmith, and worked with him at that business about one year. He found, however, that this business was too laborious for him, and relinquished it to become an apprentice to a carpenter, joiner, and boat-builder, with whom he served a full apprenticeship, during which time he was employed in almost every department of woodwork. The prime motive which actuated him through all these years that he had worked at the bench was his thirst for knowledge. He felt sure that, with his trade as his capital, he could work his way through a course of study. In pursuance of this idea, after the time had expired for which he had apprenticed himself, he began a regular course of study, and, by working a portion of each day and during vacation at his trade, was enabled to pay his necessary expenses and keep up with his class. Here, as everywhere else, the capacity and ability to master everything relating to physical science was perhaps the most prominent characteristic exhibited during his collegiate course. While studying natural philosophy, it was his custom to make and carry with him into the class such apparatus as could be readily constructed and would serve to illustrate the lesson. His habit of actually constructing everything which he saw or read of, so far as his facilities would allow, was the best possible method of fixing the principles of its operation firmly in his mind.

Mr. Gray's career as a professional electrician and inventor dates from the year 1865. His first patent for electrical or telegraphic apparatus was granted October 1, 1867. Since that time he has made a considerable number of electrical inventions, many of which have been patented. Including cases now pending, the number amounts to about forty in this country and thirty in foreign countries. Thirty of the United States cases and twenty-five of the foreign relate to the telephone.

His attention was first called to the subject of telephonic transmission in the winter of 1867. In the course of his experiments during this winter and spring, he made use of a vibrating electrotome or reed in the primary circuit of an induction coil, and an electro-magnet having a polarized armature, in the secondary circuit. A Morse transmitting key was also inserted in the last-mentioned circuit. When the electrotome was in operation, and the Morse key in the secondary circuit was closed, he noticed a singing sound in the electro-magnet, and, by working the key as if transmitting a Morse message, the signals were audibly produced on the magnet by long and short sounds, representing the dots and dashes of the Morse alphabet. He saw in it a method for transmitting signals for telegraphic purposes, and also about the same time conceived the idea of arranging a key-board, having electrotomes tuned to the different tones in the scale. He did not, however, at this

time realize the full value of the invention, as his attention was mainly directed to the capacity of the apparatus for transmitting musical tones through an electric circuit.

In the winter of 1874 Mr. Gray observed a singular circumstance in connection with the reproduction of electrically transmitted vibrations through the medium of animal tissue. On going into the bath-room he found his nephew playing with a small induction coil—"taking shocks," as he expressed it, for the amusement of the smaller children. He had connected one end of the secondary coil to the zinc lining of the bath-tub, which was dry at that time. Holding the other end of the coil in his left hand he touched the lining of the tub with the right. In making contact, his hand would glide along the side for a short distance. At these times Mr. Gray noticed a sound proceeding from under his hand at the point of contact, which seemed to have the same pitch and quality as that of the vibrating electrotome, which was within hearing. Mr. Gray immediately took the electrode in his own hand, and, repeating the operation, to his astonishment found that, by rubbing hard and rapidly, he could make a much louder sound than the electrotome was making. He then changed the pitch of the vibration, increasing its rapidity, and found that the pitch of the sound under his hand was also changed, it still agreeing with that of the transmitted vibration. He then moistened his hand and continued the rubbing, but no sound was produced so long as his hand remained wet ; but, as soon as the parts in contact became dry, the sound reappeared. So striking was the effect that, by hard rubbing with the dry hand, the noise could be distinctly heard throughout the house.

This experiment produced a profound impression upon his mind, and determined him at once to take the matter up in earnest and see what might be in it. He procured a violin, and, taking off the strings, substituted in their place a thin metal plate provided with a wire connection, so that he could attach it to one pole of the induction coil or battery, thus placing it in the same position, with reference to the body, that the bath-tub was in the original experiment. By rubbing the plate in the same manner as before described, the sound of the electrotome was reproduced, accompanied by the peculiar quality or timbre belonging to the violin. He noticed, however, that the characteristics of the initial vibrations were faithfully preserved, and all that was needed was to sift out such foreign vibrations as were excited in the receiver, owing to its peculiar construction; in which case there would remain the exact character of the transmitted vibrations.

In March, 1874, Mr. Gray undertook to secure letters patent for some of his conceptions, and with that purpose in view had models made, illustrating the idea of a series of transmitters, each tuned to a different pitch, showing a method of receiving musical or other sounds telegraphically, through the medium of animal tissue. In June, 1874, he filed another case, substituting for the animal-tissue receiver an

electro-magnet combined with a hollow box of tinned iron, having an opening in one side, while the other was held over the poles of the magnet at such a distance from it as would produce the best effect. With this apparatus he noticed that when he depressed two keys on his transmitter, if these were in the proper relation to each other, a composite tone would be received, thus demonstrating the general fact that, with a transmitter and receiver properly constructed and arranged in the circuit, composite tones of varying quality could be telegraphically transmitted and received.

When the fact dawned upon him, and had been confirmed by demonstration, that sounds of a composite character could be transmitted through a telegraphic circuit and reproduced at the receiving end, and the possibilities of the invention and the great results to which it must eventually lead passed through his mind, he at once foresaw so many possible applications of it that it became a serious question which line of investigation to first pursue. Among other conceptions of the probabilities of the invention was that, at an early day, not only musical compositions of a complicated character, but even articulate speech, would be transmitted through a single telegraph wire. He could also see that musical tones, differing in pitch, could be simultaneously transmitted through the wire and analyzed at the receiving end, so that a transmitter and a receiver correspondingly tuned would transmit and receive a tone corresponding to their own pitch, rejecting all others; while at the same time a number of other tones differing in pitch might be simultaneously transmitted and received through the same wire. This he successfully accomplished, sending as many as eight messages simultaneously. Another conception which occurred to him at this time was that of applying the invention to a printing telegraph, so that each type would be actuated by a tone of a particular pitch. Being well conversant with the facts, so far as they were then known in the science of electricity and magnetism, he was fully prepared to avail himself of what had already been done in that line. He was not, however, experimentally conversant to the same extent with the facts in the science of acoustics, but theoretically the subject was a familiar one to him. He devoted considerable time to familiarizing himself experimentally with that science, especially that branch which related to the qualities of composite tones; so that he was able to give the composition of the various vowel sounds, and determine in general the relation between the character of a sound as it seemed to the hearer and the physical fact as it existed in the form of motion, either in the air or any medium through which it was propagated.

The early part of 1874 he devoted principally to the construction of various devices for telegraphically transmitting musical tones. Among the receivers which he used was an electro-magnet with a circular diaphragm made of a thin sheet of tinned iron. It will be observed that this instrument embraces all the substantial features in the mechanical

construction of the speaking telephone of to-day. When used in connection with his articulating transmitter, which was developed at a later date, articulate words have been received upon it; and when a duplicate of the instrument is inserted in a closed circuit, which includes a galvanic battery, it becomes a speaking telephone capable of acting both as a transmitter and as a receiver. Mr. Gray did not know at that time, however, that he could use it as a transmitter, although he had fully demonstrated its ability to receive sounds of varying quality. At that date his conception of a transmitter for the transmission of articulate words was a mechanism which would employ such tones as were needed, and would enable one to manipulate them in whatever manner was requisite to produce the desired effect. In other words, he supposed it would be necessary to construct a mechanism similar to the vocal organs of the throat, which would mold electrical waves into the same form that the air is molded when a spoken word is uttered. This seemed too complicated a machine to be easily constructed; hence he determined to experiment particularly in the direction of the more perfect transmission of composite tones, so that each individual tone would have its individuality and place properly preserved in the clang of which it was a part; and to the analysis of the same at the receiving end, so that any particular tone would respond upon one instrument, and one only. This general result once attained, it was his purpose to make an application of it to multiple, printing, and autographic telegraphy. While engaged in these experiments he was continually on the alert for developments that might assist him to solve the interesting problem already before his mind, that of transmitting spoken words. Shortly after he constructed a transmitter, consisting of a revolving shaft, upon which were mounted two eccentric cams, having one or more projections. These actuated two small levers, causing them to vibrate upon their respective break-points, through which points a battery current passed. He employed, in connection with this transmitter, a receiver which was adapted to the reception of all varieties of sounds.

When this apparatus was put in operation a sound of peculiar quality, not unlike that of the human voice when in great distress, proceeded from the receiver. By altering the tension of the spring in various ways he was able to imitate many different sounds involving the vowels only, and succeeded, among other things, in producing a groan with all its inflections in the greatest perfection. Up to the time of making this experiment Mr. Gray had associated in his mind, in connection with transmission of spoken words, a complicated mechanism. This experiment produced an entire change in his views, and he came to the conclusion that in solving the problem of transmitting spoken words it was not necessary to consider the mechanism of the vocal organs at all, but simply the physical results produced in the atmosphere by them, and all that was necessary, therefore, was to devise a transmitter that would

reproduce electrically an exact copy of the atmospheric vibrations produced by any sound whatever.

During a visit in Milwaukee at this time, Mr. Gray saw for the first time a toy called the lovers' telegraph, consisting of a membrane stretched over the end of a tube, and having a thread attached to the center, the other end of which was attached to a similar membrane. The fact that spoken words were distinctly transmitted by the longitudinal vibrations of the thread from one membrane to the other confirmed the idea that he had formed a year previous; and it immediately solved in his mind the problem of making a transmitter that would copy electrically the physical vibrations of the air produced by articulate sounds. He determined to put this into practical shape, and file it in the records of the Patent-Office. He accordingly put his speaking telephone into the form of drawings and specifications, and filed them in the United States Patent-Office, February 14, 1876. In his specification he states that he has invented a new art of telegraphically transmitting vocal sounds whereby the tones of the human voice can be transmitted through a telegraphic circuit, and reproduced at the receiving end of the line, so that actual conversations can be carried on by persons at long distances apart, and that he has devised an instrument capable of vibrating responsively to all the tones of the human voice, and by which they are rendered audible.

His method of providing an apparatus capable of responding to the various tones of the human voice was a diaphragm stretched across one end of a chamber, carrying an apparatus for producing fluctuations in the potential of the electric current, and consequently varying in its power. The vibrations thus imparted were to be transmitted through an electric circuit to the receiving station, in which circuit was included an electro-magnet of ordinary construction, acting upon a diaphragm to which was attached a piece of soft iron, and which diaphragm was stretched across a receiving vocalizing chamber, similar to the corresponding vocalizing chamber at the transmitting end.

This is the first description on record of an articulating telephone which transmits and reproduces the spoken words of the human voice at a distance by means of electricity, and instruments constructed in exact accordance with Mr. Gray's drawings and specifications, filed at the time above stated, are good articulating telephones. Moreover, Mr. Gray's method of producing articulate speech by varying the resistance of a battery current is much more effective than that of Professor Bell subsequently invented, which depends upon magneto-induction currents generated by the action of the voice, as is fully proved by the great superiority of Edison's carbon telephone, which is based upon this principle.

CORRESPONDENCE.

DR. LARDNER AND TRANSATLANTIC STEAM-NAVIGATION.

To the Editors of the Popular Science Monthly.

GENTLEMEN: In your December number, under the heading "Editor's Table," you Socratically repeat the statement that Dr. Lardner declared that steam-navigation across the Atlantic was impracticable. This statement you will find on examination to be incorrect; and, as I consider that your publication is well adapted to make known the facts in the case, I transmit them to you, in the hope that you will publish them, and so contribute to their becoming generally known. Scientific men, as necessarily lovers of truth and exactness, can not but desire that such a statement should not be continued unless founded on the basis to which it pretends. General readers will soon adopt the correction of the error if properly laid before them, notwithstanding a possible bias toward enjoying what they at present regard as a disproved fallacy advanced by a very able man. The facts are as follows:

In 1828 there was published in New York, by Elam Bliss, 128 Broadway, an edition of Dr. Lardner's "Popular Lectures on the Steam-Engine, . . . with additions by James Renwick, Professor of Natural Experimental Philosophy and Chemistry in Columbia College, New York." Mr. Renwick in his preface says: "A few additions have been considered necessary. . . . They may be distinguished from the original paragraphs of the text from their being marked by letters instead of numbers, and their having the initials A. E. subscribed to each of them."

At page 157 of the work I refer to, the eleventh lecture of Dr. Lardner will be found to commence with this proposition: "One of the most interesting and important uses of the steam-engine is its application to *nautical purposes*. There are *various ways* in which this machine may be used in propelling a vessel through *the deep;* but that which is *now universally adopted* is by giving, through its means, rotation to paddle-wheels placed at the side of the vessel." And Dr. Lardner further on says: "In 1812 steam-vessels were first introduced upon the Clyde, and since that period steam-navigation has rapidly extended, so that at present there is scarcely a part of the civilized globe to which it has not found its way. *The Atlantic and Pacific Oceans* have been traversed by its powers, and if the *prolific results* of human invention should suggest means of diminishing the consumption of fuel, or obtaining a supply of heat from materials sufficiently small and light, *it would be hard to assign limits to the powers of this most wonderful agent.*"

Now, we have here from Dr. Lardner the broadest statement possible from so careful and exact a man, that he rather expected "the prolific results of human invention," not only to render "steam-navigation across the Atlantic" practicable, but to carry the uses of steam so far that he would not venture to assign limits to them. And the whole of his eleventh lecture is in this sense and tone.

But Mr. Renwick, at page 167 of the quoted work, has this note:

"(*k.*) The steam-engine may compete successfully with the wind as a propeller of vessels, whenever certainty of conveyance becomes important, as in the case of passage-boats upon lakes and rivers. But *there are cases where steam becomes inapplicable to navigation. Upon the open ocean*, although the safety of steamships has been fully tested, *the vast quantity of fuel necessary in a long passage will prevent its use* in distant voyages, and it is besides far less economic than the propulsion by means of sails. (A. E.)"

I have italicized a few of the more important words in these extracts, which show that it was not Dr. Lardner but Mr. Renwick who has to take the responsibility of having said that "steam-navigation across the Atlantic was impracticable."

Respectfully,

JAMES BURNS, M. D.

NEW ORLEANS, *December* 7, 1878.

INSECTS AND COLORED FLOWERS.

To the Editors of the Popular Science Monthly.

DURING the summer I have spent much of my time in a porch surrounded by petunias and morning-glories, of all shades of color from white to bright purple and dark violet. I first observed that the colored petunias were torn to pieces every day before noon, while the white or pale ones escaped almost uninjured. I soon discovered that the bees and butterflies were the mischief-makers, and that the damage was done with their sharp claws in struggling to get to the bottom of the flower-cup. I kept a close watch down to the present day—when the bees and butterflies are gone, and a few blossoms still remain, never molested—and

my first impressions have been fully confirmed. In every variety of situation and circumstances the white petunias have been neglected for the colored, in exact proportion to the intensity and vividness of color; and the same I found to be true, in a less degree, as regards the deep and pale morning-glories. I have called the attention of others to the facts, and proved that the preference of the insects is determined by color alone. If there was any difference whatever in sweetness or fragrance, it was in favor of the rejected white flowers.

Yours respectfully,

THOMAS D. LILLY.

KENT'S STORE, FLUVANNA COUNTY, VA., *October* 23, 1878.

AN AMERICAN HAIRY TORTOISE.

To the Editors of the Popular Science Monthly.

NOTICING your interesting extract, from "Land and Water," concerning the hairy tortoise, I take the liberty of mentioning a similar species found, to my knowledge, in the lakes of this valley. Its description tallies almost exactly with that of the Chinese variety, except perhaps in size. It is about three inches in length by two and a half in breadth, is very closely covered by its shell; the calipee is not hinged, and out of some dozen specimens examined by me not one was without the coat of water-grass. Its habitat is the bottom of shallow lakes and ponds, and near the submerged roots of trees, where it is often caught with the hook. It has a remarkably fetid odor. The grassy or confervoid covering is not of any very great length, generally about one half or three fourths of an inch. It is, I believe, an undescribed species, though Mr. Agassiz may have had a specimen among his collection of tortoises from the Mississippi Valley.

Very respectfully,

J. F. BATTAILE.

YAZOO CITY, MISSISSIPPI, *December* 8, 1878.

EDITOR'S TABLE.

COPYRIGHT AND MORALITY.

THE recent fluttering among American publishers caused by the discovery that Canadian enterprise threatens to come into successful rivalry with them, even in their own home market, is sufficiently amusing. The violation of the rights of foreign authors has been hitherto excused on the ground that it was necessary to the promotion of American popular education and indispensable to the intelligence of the country. Authors and publishers, we have been emphatically told, are by no means the main parties to be considered in this matter; both must be subordinated to the requirements of cheap literature for the reading public of the United States. This sounds patriotic and disinterested, and we might almost be persuaded to assent and admire, were it not for the odd circumstance that those who talk loudest in this strain seem to have been the most successful in feathering their own nests at the expense of the dear people whose interests they have so much at heart. The American publisher has been virtually saying to Jonathan and his family, who, it is presumed, were intensely hungering for knowledge, "By not paying the foreign author I am able to provide you with his productions many times cheaper than you could otherwise get them"; and it has been agreed that it was a very nice arrangement, highly favorable to American intelligence, which it might be a national disaster to disturb. But when the Canadian publisher offers to join in this noble philanthropic work of educating Jonathan and his family by cheap literature, we are surprised to observe that he gets the cold shoulder. He says to Jonathan and his family, "By not paying *American authors* I can furnish you with their productions many times cheaper than you can otherwise get them," and this he is proceeding to do by means of the post-office. But, instead of welcoming this efficient coöperation of the Canadian publishers for cultivating and illuminating the American mind, our publishers are quite disgusted, and say this thing must be stopped, which simply shows what

former pretensions have been worth. This northern gust will blow the dust away from many people's eyes.

But the American people ought not to have waited for this. It should have been settled on grounds of justice for the benefit of the national character. It is a serious question and a plain one—not easy to adjust, but still wholly practicable. It is one of those palpable matters in which where there is a will there is certain to be found a way. One of the worst things about it is that our practice shows to the world the low and disgraceful state of American morality. We have published the evidence of Huxley, Tyndall, and Spencer before the English Commission on Copyright, and every one who has read it will be struck by the clear and elevated ethical tone that pervades it. These men are thought by many to be very bad, but they are men who know what is right and believe in it and maintain it unflinchingly. Has the occupant of one American pulpit ever been known to call attention to this great national disgrace? International copyright is one of those questions that measure the degree of civilization. It indicates the high-water mark of the public conscience, the strength of the sense of justice, and how far it is overborne by the dictates of self-interest. It is a case in which wrong may be perpetrated with apparent impunity. More obtrusive questions which arise between people of different countries are liable to be complicated with fear, and justice is often extorted by a dread of the consequences of withholding it, rather than by the simple force of the conviction of right. But authors can't fight for their rights, nor will governments protect them by the force of arms. They must be content, therefore, to appeal to the moral sense and the sentiment of public honor. Military redress being out of the question, there remains only the resort to those civil agencies by which private rights are protected, and the vigor with which these act under the inspiration of public feeling tests the degree of civil progress or the condition of civilization. From this point of view the American Republic occupies the lowest place among the leading nations of the civilized world; and from the scorn of all honest men we can only escape by setting this matter right by some form of national action.

And the naked right of the case is palpable enough, though, from the obtuseness or indifference of the popular mind upon the subject, it can not be too frequently or too forcibly presented. What we have written elsewhere upon this point we now repeat, that it may have a more permanent record:

The basis of an author's right of property in the book he makes is the same as the farmer's right in the wheat he raises. They are each the product of capital and labor. In one case capital is invested in land, implements, and stock; in the other it is invested in education, books, and suitable arrangements for literary life; while in both the product is the direct result of work done. The property in his work belongs to an author because there has been expense in its preparation, and because he has produced it by his immediate personal exertion. It is his to possess and to profit by its proceeds, by all the principles of justice which confer the ownership of any property. Questions may arise respecting acquired rights in literary property; but the original right of him who called it into existence by his own labor is clear and beyond question.

It is often said that ideas are ethereal things, and belong to the spiritual world, and therefore can not become subject to ownership; that is, not being material property, they can not be real property. Others, again, curiously affirm that ideas may be property while yet in the thinker's mind, but cease to be so the moment they are sent forth and made useful to others; or that thought until expressed or published is the property of the thinker; when given to the world, like light, it is free to all. Now there is, of course, a profound difference between ideas and material commodities, but there is no such difference as is here implied. They are both products of human exertion. A sonnet is as much the result of bodily effort as a horseshoe. The author works with one material instrument, the

mechanic with another. The mechanic produces a hat, for example, by muscular action; and the author produces a book by brain action. In both cases the result represents vital power continuously expended; there has been exhaustion of the bodily energies in both cases alike. The blood represents the stock of vital power, and it is drawn upon in muscular action by the laborer and in cerebral action by the author. An author, too, has need for a large amount of blood to sustain his thinking. Physiologists tell us that the brain is more immediately dependent upon a copious supply of blood than any other part of the system. They say that, although the average brain is but one thirty-sixth the weight of the body, it demands one fifth of all the blood to keep it in working order. Ideas, then, are bodily products, and are at the expense of the blood; and the books containing them represent the life-forces and spent vitality of their authors. The elements of blood come from the market and have their price. Food and clothing, and the conveniences of living, are neither sent to authors from heaven, nor are they furnished gratuitously by government. Like other people, those who make books depend upon their labor to live, and they have an equal right with other people to the fruits of their labor.

Because ideas go forth in a subtile way, and are widely diffused, is no reason for regarding them as "free as the light," to be appropriated by anybody without paying their originators. If they are real and tangible enough to steal, they are capable of protection as property. It is in no sense a question of the form or quality of the things produced, for these are but accidents. If an author is to be robbed because his property is in an ethereal shape, why not rob the milkman because his property is in a liquid shape? Whether a man devote his powers to the elaboration of thought or the elaboration of matter is perfectly immaterial so far as concerns the question of his property right in the thing produced.

But we may go further and ask what property can have so sacred a right of recognition as that which is the product of man's highest faculties? The creations and constructions of the brain, as they have a far higher value to the world than the mere products of material manipulation, have also a more transcendent and inviolable claim to the protection of law. The hand is but the servant of the intellect. All knowledge, art, science, literature, discovery, invention, all that redeems man from barbarism and creates civilization, are but results of brain-exertion; and are we to discredit this noblest form of effort and outlaw the men whose lives have been consumed by it, while all the guards of legislation are thrown round the grosser forms of manipulative industry?

But it will be said all this is clear enough—why multiply wearisome commonplaces? Most true, and if our practice conformed to these professions, nothing would need to be said. But our practice is a direct contradiction to admitted and self-evident justice, and this is a state of things that can not be let alone. We affirm an author's right in his work, and then we proceed systematically to rob him of it. We are not only thieves, but thieves proclaiming in open day that we know ourselves to be so. To be sure, it is foreign authors whom we rob, but this does not affect the case, as the rights of private property are coextensive with civilization. It will hardly do to object to a "foreigner" when we appreciate his work so highly as to covet it and take it from him wrongfully. His case against us is clear enough. He says: "I have produced my book at much expense and with hard labor. I have created property in it; you want it, and in taking it you attest its value; you appropriate it to enrich yourselves without giving me a just equivalent; you steal it, and your Government protects you in it as if it were an innocent act." The logic is short and decisive, and it leaves this country in no very enviable position in the community of nations. Claiming to be civilized, enlightened, and even Christian, we practice an ethical code in this matter not higher than the standard of savages. Were our Government founded in usurpation and injustice, as we assert the European Governments to be, there would be a kind of consistency in maintaining this admitted wrong; but, while the monarchical countries have cleared themselves of all complicity in it, it is reserved for the people who boast of the "best government on earth," and who fill the world with their boasts about "human rights," to maintain an organized system of literary brigandage in which private rights are unscrupulously violated, and the highest products of man's exertion are the objects of indiscriminate plunder. It is a case, moreover, in which meanness is added to dishonesty. We take from its owner that which he is powerless to protect. We steal that which is confided to the public honor, and, as if this were not enough, we add hypocrisy to meanness by putting forth palavering pretexts for our action. There are

those who say the present state of things should not be meddled with, and rake up excuses for continuing it. It is bad to steal; it is despicable to steal from our benefactors who happen to be compelled to trust us; but more despicable still is the shameless Jesuitism by which an interested party will seek to defend it. When listening to the sneaking apologies that are put forward in extenuation of such conduct, we feel as if the mere common thief might rise in self-respecting wrath and kick the pettifogging poltroon out of his society.

Two things in relation to copyright may now be considered established as completely as anything can be established by the concurrent usage of the civilized world. By the declaration and the practice of all nations it has been settled, first, that an author has a right of property in his work, which government is bound to protect; and, second, that the public also has rights by which those of the author are restricted. There are extremists who maintain that an author's rights of property are absolute and perpetual, and other extremists who hold that there can be no such thing as exclusive property in ideas—just as there are those who maintain that "all property is robbery." Practical legislators may well assume that these conflicting views cancel each other, and may safely proceed to action on the basis of broad experience and the general agreement of nations.

LOCKYER ON THE CHEMICAL ELEMENTS.

Mr. Lockyer's paper before the Royal Society on the compound nature of some of the so-called elements from the point of view of spectrum analysis has attracted the attention properly due to the eminence of the investigator in the latter field, but chemists will be slow to admit that the experimental aspect of the subject has been much altered by Mr. Lockyer's investigations. The *a-priori* grounds for believing that the so-called elements are not elementary were already strong. In fact the progress of chemistry had proved many substances to be compound which were previously ranked as elements, and left the list of simple bodies to consist of such only as have hitherto resisted analysis. It has long been believed that the relations among the atomic numbers furnish strong evidence of the compound nature of many substances classed as elementary; and spectrum analysis has served greatly to heighten this probability. When, a few years ago, Dr. Martineau made an assault upon the doctrine of evolution, one of his objections to it was that the universe started a long way ahead on the line of *heterogeneity* by its outfit of chemical elements; the implication being that these elements had to be separately created before evolution could begin. To this, Herbert Spencer cogently replied that the elements are not *known* to be elementary; that no intelligent chemist holds them to be absolutely so; and that many concurrent considerations compel the inference that they are compounded, and perhaps recompounded of a few and perhaps of a single primordial constituent. The bearings of spectroscopic research upon the question were thus stated: "Spectrum analysis yields results wholly irreconcilable with the assumption that the conventionally named simple substances are really simple. Each yields a spectrum having lines varying in number from two to eighty or more, every one of which implies the intercepting of ethereal undulations of a certain order, by something oscillating in unison or in harmony with them. Were iron absolutely elementary, it is not conceivable that its action could intercept ethereal undulations of eighty different orders: though it does not follow that its molecule contains as many separate atoms as there are lines in the spectrum, it must clearly be a complex molecule. Still more clearly is this general implication confirmed by facts furnished by nitrogen, the spectrum of which has two quite different sets of lines, and changes from one set to the other as the temperature is varied. The evidence thus gained points to the conclusion that, out of some primordial units, the so-called elements arise, by

compounding and recompounding; just as by the compounding and recompounding of so-called elements there arise oxides and acids and salts."

Mr. Lockyer aims to enforce these views by fresh illustrations. The following passages from an account of his paper written for the "London Times," by a chemist who heard it, will give a fair idea of its quality:

There are many facts and many trains of thought suggested by solar and stellar physics which point to the hypothesis that the elements themselves, or at all events some of them, are compound bodies. Thus it would appear that the hotter a star the more simple is its spectrum; for the brightest, and therefore probably the hottest stars, such as Sirius, furnish spectra showing only very thick hydrogen lines and a few very thin metallic lines, characteristic of elements of low atomic weight, while the cooler stars, such as our sun, are shown by their spectra to contain a much larger number of metallic elements than stars such as Sirius, but no non-metallic elements; and the coolest stars furnish fluted band-spectra characteristic of compounds of metallic with non-metallic elements and of non-metallic elements. These facts appear to meet with a simple explanation if it be supposed that as the temperature increases the compounds are first broken up into their constituent "elements," and that these "elements" then undergo dissociation or decomposition into "elements" of lower atomic weight. Mr. Lockyer next considers what will be the difference in the spectroscopic phenomena, supposing that A contains B as an impurity and as a constituent. In both cases A will have a spectrum of its own. B, however, if present as an impurity, will merely add its lines according to the amount present, as we have above explained; whereas if a constituent of A it will add its lines according to the extent to which A is decomposed and B is set at liberty. So that as the temperature increases the spectrum of A will fade if A be a compound body, whereas it will not fade if A be a true element. Moreover, if A be a compound body, the longest lines at one temperature will not be the longest at another. The paper chiefly deals with a discussion from this point of view of the spectrum of calcium, iron, hydrogen, and lithium, as observed at various temperatures; and it is shown that precisely the kind of change which is to be expected on the hypothesis of the non-elementary character of the elements has been found to take place. Thus each of the salts of calcium, so long as the temperature is below a certain point, has a definite spectrum of its own, but as the temperature is raised the spectrum of the salt gradually dies out and very fine lines due to the metal appear in the blue and violet portions of the spectrum. At the temperature of the electric arc the line in the blue is of great intensity, the violet H and K lines, as they are called, being still thin; in the sun the H and K lines are very thick, and the line in the blue is of less intensity than either, and much thinner than in the arc. Lastly, Dr. Huggins's magnificent star photographs show that both the H and K lines are present in the spectrum of α Aquilæ, the latter being, however, only about half the breadth of the former; but that in the spectrum of α Lyræ and Sirius, only the H line of calcium is present. Similar evidence that these different lines may represent different substances appears to be afforded by Professor Young's spectroscopic observations of solar storms, he having seen the H line injected into the chromosphere seventy-five times, the K line fifty times; but the blue line, which is the all-important line of calcium at the arc temperature, was only injected thrice. In the spectrum of iron two sets of three lines occur in the region between H and G, which are highly characteristic of this metal. On comparing photographs of the solar spectrum and of the spark taken between poles of iron, the relative intensity of these triplets is seen to be absolutely reversed; the lines barely visible in the spark photograph being among the most prominent in that of the solar spectrum, while the triplet, which is prominent in the spark photograph, is represented by lines not half so thick in the solar spectrum. Professor Young has observed during solar storms two very faint lines in the iron spectrum near G injected thirty times into the chromosphere, while one of the lines of the triplet was only injected twice. These facts, Mr. Lockyer contends, at once meet with a simple explanation if it be admitted that the lines are produced by the vibration of several distinct molecules.

The lithium spectrum exhibits a series of changes with a rise of temperature precisely analogous to those observed in the case of calcium.

In discussing the hydrogen spectrum, Mr. Lockyer adduces a number of most important and interesting facts and speculations. It is pointed out that the most refrangible line of hydrogen in the solar spectrum, *h*, is only seen in laboratory ex-

periments when a very high temperature is employed, and that it was absent from the solar protuberances during the eclipse of 1875, although the other lines of hydrogen were photographed. This line also is coincident with the strongest line of indium as already recorded by Thalén, and may be photographed by volatilizing indium in the electric arc, whereas palladium charged with hydrogen furnishes a photograph in which none of the hydrogen lines are visible. By employing a very feeble spark at a very low pressure the F line of hydrogen in the green is obtained without the blue and red lines which are seen when a stronger spark is used, so that alterations undoubtedly take place in the spectrum of hydrogen similar to those observed in the case of calcium. In concluding this portion of his paper Mr. Lockyer states that he has obtained evidence leading to the conclusion that the substance giving the non reversed line in the chromosphere, which has been termed *helium*, and not previously identified with any known form of matter, and also the substance giving the 1,474 or coronal line, are really other forms of hydrogen, the one more simple than that which gives the *h* line alone, the other more complex than that which gives the F line alone.

There can be no question that the facts brought forward by Mr. Lockyer are of the highest importance and value, and that they will have much influence on the further development of spectrum analysis, to which he has already so largely contributed. But his arguments are of a character so totally different from those ordinarily dealt with by chemists that they will hesitate for the present to regard them as proof of the decomposition of the elements until either they are assured by competent physicists that they can not be explained by any other equally simple and probable hypothesis, or until what Mr. Lockyer has foreshadowed as taking place to such an extent in other worlds has been realized beyond question or cavil in our own laboratories.

LITERARY NOTICES.

The Commonwealth reconstructed. By Charles C. P. Clark, M. D. New York: A. S. Barnes & Co. 1878. Pp. 216. Price, $1.50.

This is a suggestive work on the philosophy of American politics, made up of two parts logically related but very dissimilar in character. The first half of the book is devoted to an examination of the tendencies of our political system, which are arraigned as, in their working, a disappointment and a failure. This portion of the work is important, as giving a large amount of information on the morbid anatomy and the diseased functions of the body politic. The facts are interesting and copious, but we regret that Dr. Clark has not guarded himself here against criticism by the more full and more careful citation of his authorities. For example, when he says, "Since 1870 more judges have been impeached, or have resigned to avoid impeachment, than in all our history before," or when he says, "The British Parliament, though it unites the powers and functions of all our separate State Legislatures and constitutional conventions, and manages half a hundred colonies and a fourth part of the population of the earth, does not pass as many laws annually as the State of New Jersey," we should like to be informed of the exact data on which these assertions rest. More care in this direction would have given to Dr. Clark's work a higher and more permanent value.

After pointing out, in his opening chapters, the numerous indications of our political degeneracy, the growing venality in public life, the increase of official crime, the augmenting incompetency of public men, the deeper corruption of parties, and the enormous increase of taxes, resulting from scandalous misgovernment—having, in fact, made out a strong and dark indictment against our political system, Dr. Clark then takes up the various causes and remedies that have been proposed for this bad state of things. He thinks the fault is not to be laid at the door of human nature, nor is the democratic principle to be blamed. The nation is not overgrown, our political evils are not the "aftermath of the late civil war," and our difficulties are chargeable neither to the Democratic nor the Republican party. They are such, moreover, as can not be rectified and removed by any of the usual expedients of reform, such as constitutional amendments, minority representation, cumulative voting, female suffrage, outlawry of the lobby, commissions of investigation, nonpartisan organizations, religion, moral renovation, education, or civil-service reform. The writer goes rapidly over this field, showing the weak places and the general

futility of these various remedial measures, and sums up that there is no hope in them, as follows:

> But these and many other various explanations and remedies for our evil case, that have been heretofore offered to the anxious inquiries of the people, hardly deserve so much attention. The explanations are incompetent and the remedies nugatory. He who expects to see statesmanship and fidelity to the public interests restored in city, State, or nation by civil-service reform, the restraint of special legislation, long presidential terms or short; a new settlement of functions among aldermen, commissioners, and mayors; the election or the appointment of judges; closer investigations or severer punishments; an educational test, a religious test, or a property test; or any other the like petty and partial devices, would expect to cure the yellow fever by changing a man's shirt.

This is strongly put, but we are inclined to think that the author is a good deal more than half right.

Dr. Clark thus discredits all the nostrums offered by the political doctors to cure the diseases of the body politic; but to what end? Not to confirm the conclusion, made infinitely probable by his own sweeping logic, that the case is not one to be cured by nostrums at all; but, strange to say, the other political medicine-men are dismissed, that our doctor may try a new nostrum of his own. His panacea *may* be effectual—it has not been tried—but we are sorry to note that it is put upon the usual quackish ground at the outset. Every sovereign cure assumes unity of cause in all diseases—"all maladies come from impurity of the blood, you know; here is something to purify the blood." Dr. Clark says, "The political rot in all the larger spheres of government is identical and pervading; it must own some single cause as dominating as gravity itself; and it must find a single cure."

The true root of our political difficulties is assumed to be the present organization of polities, represented chiefly by the caucus system, the result of which is, that "*at the dictate of leaders whom we have not chosen, we vote for candidates whom we do not know, to discharge duties that we can not understand.*" The remedy proposed is embodied in the proposition that popular elections work well in small and ill in large constituencies. The general purity of town and village politics is contrasted with the general corruption of municipal, State, and national politics, and the cause of this is alleged to be that, in the former case, the citizen knows who and what he is voting for, while in the latter case he knows little or nothing of either. There is therefore required a new method of elections—a reconstruction of the commonwealth by which the voter shall commit to competent men, whom he knows, the function of appointing all higher officials in the larger spheres of political action. The sovereign citizen is, in fact, to recognize his incompetency to deal with general politics, to abdicate his vote, on State and national questions, and choose those whom he thinks better able to do all this business for him. Dr. Clark does not propose to dispense with caucus and organization, but that the people shall take them out of the hands of the politician and operate them themselves. He says:

> The people must turn over the prerogative of choosing Governors and Legislatures, now nominally exercised at the ballot-box, to representative delegates. In the business of all large constituencies, the caucus and convention must be substituted for the polls. Thus only can the function of the voter be accommodated to his intelligence; and thus only, the shadow of power discarded, can we secure its substance.

For the details of his plan, the interested reader must be referred to Dr. Clark's work, where they are fully elaborated. Looking into it with some care, we have much the same opinion of it that its author very plainly expresses of other devices for the renovation of our politics and the salvation of the country. None the less we heartily commend his book to political readers, who will find much in it worthy of serious consideration.

Researches into the Early History of Mankind and the Development of Civilization. By Edward B. Tylor, D. C. L., LL. D., F. R. S. New York: Henry Holt & Co. 1878. Pp. 388. Price, $3.50.

This volume consists of a series of somewhat miscellaneous essays bearing upon the early history of man. In the view of the author, while there are great masses of materials already at hand for working out the subject, the time for writing a systematic treatise does not yet seem to have come. For civilization, being a process of long and

complex growth, can only be thoroughly understood when studied through its entire range; as the past is continually needed to explain the present, and the whole to explain a part. The matters here discussed have been chosen, not so much for their absolute importance as because, while they are among the easiest and most inviting parts of the subject, it is possible so to work them as to bring into view certain general lines of argument which apply not only to them, but also to the more complex and difficult problems involved in a complete treatise on the history of civilization.

The book contains essays upon "Gesture Language"; "Word Language"; "Picture-Writing and Word-Writing"; "Images and Names"; "Growth and Decline of Culture"; "The Stone Age, Past and Present"; "Fire, Cooking, and Vessels"; "Some Remarkable Customs"; "Historical Traditions and Myths of Observation"; "Geographical Distribution of Myths"; and "Concluding Remarks." One or two extracts from the last chapter will give the reader an idea of the spirit in which the inquiry is pursued. The author says:

> The facts collected seem to favor the view that the wide differences in the civilization and mental state of the various races of mankind are rather differences of development than of origin, rather of degree than of kind. . . . The state of things which is found is not indeed that one race does or knows exactly what another race does or knows, but that similar stages of development recur in different times and places. There is reason to infer that our ancestors in remote times made fire with a machine much like that of the modern Esquimaux, and at a far later date they used the bow and arrow, as so many savage tribes do still. The foregoing chapters, treating of the history of some early arts, of the practice of sorcery, of curious customs and superstitions, are indeed full of instances of the recurrence of like phenomena in the remotest regions of the world. We might reasonably expect that men of like minds, when placed under widely different circumstances of country, climate, vegetable and animal life, etc., should develop very various phenomena of civilization, and we even know by evidence that they actually do so; but, nevertheless, it strikingly illustrates the extent of mental uniformity among mankind to notice that it is really difficult to find among a list of twenty items of art or knowledge, custom or superstition, taken at random from a description of any uncivilized race, a single one to which something closely analogous may not be found elsewhere among some other race, unlike the first in physical characters and living thousands of miles off. It is taking a somewhat extreme case to put the Australians to such a test, for they are, perhaps, the most peculiar of the lower varieties of man, yet, among the arts, beliefs, and customs found among their tribes, there are comparatively few that can not be matched elsewhere. They raise scars on their bodies like African tribes; they circumcise like the Jews and Arabs; they bar marriage in the female line like the Iroquois; they drop out of their language the names of plants and animals which have been used as the personal names of dead men and make new words to serve instead, like the Abipones of South America; they bewitch their enemies with locks of hair; and pretend to cure the sick by sucking out stones through their skin, as is done in so many other regions. It is true that among their weapons they have one of very marked peculiarity, the boomerang, but the rest of their armory are but varieties of instruments common elsewhere. They show but few exceptions to the general rule that whatever is found in one place in the world may be matched more or less closely elsewhere.

The author believes that "the history of mankind has been, on the whole, a history of progress." Some facts are quoted which bear on the possible degeneracy of savage tribes when driven out into the desert, or otherwise reduced to destitution, or losing their old arts in the presence of a higher civilization; but there seems ground for thinking that such degeneration has been rather of a local tnan of a general character, and has affected the fortunes of particular tribes rather than those of the world at large.

Manual of Introductory Chemical Practice. For the Use of Students in Colleges and High-Schools. By George C. Caldwell, S. B., Ph. D., and Abram A. Breneman, S. B., Chemical Professors in Cornell University. Second edition, revised and corrected. New York: D. Van Nostrand. 1878. Price, $1.50.

In its earliest form this work consisted of detached sheets for the use of students of chemical practice. Corrected by trial, they were published in book form two years ago. We have now the second edition, in which the authors, guided by their larger experience, have been able better to adapt the work to the average capacity of students. Some experiments have been modified or rejected and others introduced, and another section added to the introduction for the help of teachers. The experiments are chosen to illustrate principles, and in the performance of the experiment the stu-

dent is left to observe and describe it and trace its connection with the principle it illustrates. In this work precision and conciseness of statement are required, and the reports are subjected to critical examination by the teacher. With each copy of the book there goes a separate slip stating how much apparatus and chemicals are needed for every ten students taking this course of practice.

While in its main features the manual is introductory to a more extended course, it may still be used with profit by students who have no time or opportunity for subsequent study.

Lessons in Elementary Chemistry: Inorganic and Organic. By Henry E. Roscoe, B. A., F. R. S., Professor of Chemistry in Owens College, Manchester. New edition. New York: Macmillan & Co., 1878. Price, $1.50.

This text-book, which was first published in 1869, conforms to the metric system of weights and measures, and the centigrade thermometric scale. The most important facts and principles of modern chemistry are so presented as to give the pupil exactitude of knowledge, without which science in schools is worthless. The work was revised in 1875, and important changes were made in the organic portion, while the whole book was brought up to the level of the science of the day. The present edition, among other alterations and additions, adopts, for the combining weights of the elements, numbers derived from Sta's accurate experiments, oxygen being taken at 15·96 instead of 16. In ordinary calculations, however, the older numbers, for the sake of simplicity, are still employed.

Christ's Words as related to Science, Law, Government, History, Philosophy, Religion, and Universal Human Experience. By Prof. J. B. Turner, of Jacksonville, Illinois, author of "Three Great Races of Men," "Essays on Meteorology," "Industrial Education," etc. Springfield, Illinois: H. W. Rokker. Pp. 425. Price, $2.50.

This is an able and vigorous work by an earnest believer in the religion of Christ, the object of which is to cleave through the body of dogmatic theology that has been accumulating for centuries, and get at those simple teachings that are embodied in the words of the founder of the Christian faith. "What is it that Christ really taught, and that constitutes the essence of his religion?" is the problem that Prof. Turner puts before him and undertakes to solve. The task he has ventured upon opens a very broad field of inquiry, embracing various departments of knowledge. Prof. Turner does not claim to be an expert in all these branches of learning, but only to have considered them with reference to one controlling idea—how far they have been employed to obscure the elementary inculcations of the Master. The author is both a firm believer and a vehement doubter. He says he "does not believe that all or most of the current ideas of either religion or science, of philosophy, law, or history, are true, or in accord with the teachings of Christ. It will be forever impossible to harmonize such a medley of false assumptions with each other or with the facts of being, either natural or spiritual." It being thus assumed as out of the question to bring the chaotic schemes of belief into reconciliation, the sincere Christian has nothing left but to find out for himself that which is essential in his religion, and Prof. Turner avows no other object than to aid him in this work.

The author remarks: "What Christ actually said may be one thing; what the world has been catechised or thumb-screwed into the belief that he said may be quite another." How natural it is for the meanings of Scripture to have been distorted in the long ages of ignorance and prejudice, during which they have been a matter of conflict, is well illustrated by Prof. Turner in an example which everybody can understand. He says: "If in half a century our national Constitution, written in our native tongue, consecrated to the broadest liberty, could be perverted so that union, fraternity, and justice, were synonymous with the right of domination of white over colored men; and if our Legislatures, our courts, our army and navy, our literature, schools, and churches, our very psalms and prayers, could be marshaled and used for the defense of one of the most infamous forms of slavery the world has ever seen, what may not have been done during the ages of barbaric ignorance, with the records

of the Bible existing only in manuscript, and written in dead Hebrew and Greek?"

From Prof. Turner's chapter on "Miracle and Prayer" we quote the following passages, which illustrate his view of that subject:

> We have a cow that is, in her way, a great philosopher, and somewhat of a divine. She has attained such adroitness that she can handle all the hasps and latches, and open all the gates and barn-doors. She is clearly of the opinion that whatever lies beyond her capacity in that line must be miraculous; and when we take a key out of our pocket, and put it in a padlock, and open a door that she has tried in vain to open, she cocks her ears forward, opens her eyes, and says as plainly as she can: "Well, now, that is clearly miraculous; a manifest interference with the laws of Nature." And this is very good cow-philosophy and cow-theology; but will it do for human beings? . . .
>
> No one of the gospel narrators ever intimates that Jesus's works were either a violation or a suspension of, or even an interference with, any law of Nature. All this is our own "cow-philosophy" and "cow-divinity." It neither came from Christ nor his apostles. They spoke of them as "*signs*" and "*wonders*," "*mighty works*"; as acts that were "significant," "strange and unusual," and implying "power." In the only three ultimate forms of being or existence known to us, matter, force, and spirit, or voluntary being of some sort, the last is the only one from which any new force or cause can even seem to originate.

Prof. Turner writes with great vigor and force, though we think with some verbal redundancy, and is mainly intent upon making himself understood. He is inclined to consider that there is a good deal of credulity on the part of scientific men, and he is not very mealy-mouthed in his statement of this opinion. The following passage is evidently for the benefit of Prof. Tyndall:

> Contrast, now, the ontology, or scheme of being and destiny, implied in all Christ's teachings and works, with that implied in the dogmatism of those scientists who find "all potency in matter," beginning with their universe of star-dust and incandescent gas, without known cause, solidifying itself into the solid worlds, generating protoplasms, bioplasms, and cells, and even correlated sexes, out of dead matter, with no supervising intelligence: the molten mass of earth cooling down so slowly as to admit of ages of tropical life at the poles; and anon for ages taken with such a congestive chill that eternal ice and glaciers shrouded it quite down to the tropics; then a fever set in again, and it warmed up to its present condition, full of literal hell-fire within, eternally belching forth in all its volcanoes—all living things made out of the same original protoplasms, more handy to the modern scientist than was the dust of the earth, or Adam's extra rib, to the old Jews, but made without any maker. All things at last, in prophetic vision, to turn to ice again; all being, even the sun himself, is to freeze to death; a universe of being born without God, born at first of hell-fire, nursed on protoplasm without any nurse, and consigned at last to eternal death by frost, with still no God to breathe the breath of life into it forever more; or it may take a notion to explode again into gas and star-dust, to run its perpetual rounds, with alternate creations by hell-fire and damnations by frost, through all eternity to come! What an origin! What a destiny! What logic! What shocking assumption at every step! and what infinite dogmatism in every conclusion! What aimless and senseless credulity! Jonah and his whale, Joshua and his sun, Noah and his ark, Moses with all his snakes, and frogs, and lice, and murrains, and deaths, are totally eclipsed by these modern dealers in scientific miracles.

The American Quarterly Microscopical Journal. Edited by Romyn Hitchcock. Devoted to the Interests of Microscopical Study in all Branches of Science; with which is also published the Transactions of the New York Microscopical Society. Vol. I., No. 1. Published by Hitchcock & Wall, 150 Nassau Street, New York. Price $3 a year, or 75 cents per copy.

This is a compact, neatly printed, and beautifully illustrated journal of 96 pages, intended as an aid to professional and amateur microscopists in the promotion and diffusion of the results of research. Of the microscope and the functions of a microscopical journal the editor says:

> To the student of natural science the microscope is, and always will be, a mere tool. Microscopy, as a special science, has very little claim for existence. In so far as a certain familiarity with the instrument and training in the proper management of the light and accessories are necessary to enable one to use the instrument, it may be called a science. We would detract nothing from the merits of those who are expert in securing the most perfect performance of an objective. Still, as a matter of fact, and plain facts should not give offense to any one, we must admit that the great value of the microscope as a means of investigation lies in the aid it gives to almost every branch of science. This leads us to a statement of what, in our opinion, a microscopical journal should be. Recognizing the value of microscopical study in the various branches of natural science, such a journal should aim to publish the results of research carried on with the microscope in every department.

Accordingly, besides articles relating to the structure and improvement of the mi-

croscope itself, we find in the first number the science of zoölogy represented by papers on "The Sting of the Honey-Bee," and "On the Structure of Blood-Corpuscles"; botany by "Descriptions of New Species of Diatoms," and "On the Spore-Formation of the Mesocarpeæ"; the arts, by "The Microscopical Examination of the Fibres"; and in the next number we are promised among others an article on microscopical geology, and a study of a case of tubercular meningitis; while the subject of foods will receive attention in a paper on the microscopical characters of natural and artificial butter. From this enumeration it will be seen that the editor intends to cover a wide range of topics; and, while probably in the majority of cases the discussions will be more or less technical, many of them will also possess both popular and practical interest. The projectors of the enterprise are entitled to great credit, not only for the handsome magazine they have made, but for their courage in entering a field already the scene of many failures, and we would ask for them, not the sympathy, but the cordial support, of all who are interested in the progress of science.

Science News. Edited by Ernest Ingersoll and William C. Wickoff, of New York, and published fortnightly by S. E. Cassino, Salem, Mass. Subscription price, $2 a year.

The main object of this new periodical, as indicated by its title and expressly announced in the prospectus, is the prompt publication of scientific news, and, judging from the four numbers received, the editors are fulfilling their promise in a very satisfactory way. Each number is to contain not less than sixteen pages of matter, exclusive of advertisements, freely illustrated and presented in a style that may be readily understood by the average reader. The type is good, the price is reasonable, the editors are wide awake, and, with the advantages of thorough scientific training and long previous experience on scientific journals, are well adapted to the work—conditions certainly favorable to the production of a good magazine. Yet in one respect we think the new journal might be improved. There is news enough of a scientific character, and of both special and general interest, to more than fill such a periodical, even if it contained double the present number of pages, and to our minds this, in the form of paragraphs as brief as an intelligible statement will permit, might be profitably substituted for the more elaborate essays which now occupy the earlier pages of the periodical.

Third Annual Report of the Johns Hopkins University. Baltimore: Murphy print, 1878. Pp. 60.

Mr. D. C. Gilman, President of the Johns Hopkins University, in this report, strives to draw the line of distinction between the *college* and the *university*. The university is designed to give to those who have already received a college training or its equivalent more advanced and special instruction. To this end it must possess ample libraries, laboratories, and apparatus. Then, the holders of professorial chairs in a university must be expected and encouraged to advance by positive research the sciences to which they are devoted. For though, primarily, instruction is the duty of the professor in a university, as it is in a college, the difference of intellectual maturity between the students of the two institutions involves a difference in the respective demands of each upon the professor: university students should be so mature as to exact from their teachers the most advanced instruction, and even to quicken and inspire by their appreciative responses the new investigations which their professors undertake. An interesting feature of this report is a statement by Professor Ira Remsen, of the nature of the work done in the three scientific laboratories which form part of the Johns Hopkins University—viz., the biological laboratory, the physical laboratory, and the chemical laboratory.

Notes on a Collection from the Ancient Cemetery of Chacota Bay, Peru. By J. H. Blake. With Illustrations. From "Report of Peabody Museum of Archæology and Ethnology," 1878. Pp. 28.

The interesting collection here partly described comprises mummies, utensils, weapons, ornaments, etc. What race of people it was that buried their dead in this ancient cemetery it is impossible even to conjecture. The present Indian inhabitants of the locality claim no relationship with them.

THE TELEGRAPH IN AMERICA: Its Founders, Promoters and Noted Men. By JAMES D. REID. New York: Derby Brothers. 1879. Pp. 850. Price, cloth, $6.

WHEN in June, 1871, a strong representation of the telegraph interest in America was assembled in New York City to attend the ceremony of unveiling the statue of Professor S. F. B. Morse, in the Central Park, an earnest desire was expressed by many to have the occasion and the man appropriately commemorated in a volume. The task of composing this memorial volume was imposed upon Mr. Reid, and the completed work is now published: but instead of its being simply a monument to the memory of Professor Morse, the work has been expanded to the proportions of a history of telegraphy in America.

In accordance with the original intention of the author, the volume contains a pretty full biography of Professor Morse, with an account of the progress of electrical science down to the year 1832, when he first conceived his idea of a recording electrical telegraph. Mr. Reid was an intimate friend of Morse, and reverently cherishes his memory; but in writing this account of his friend's researches and inventions, he exhibits no desire to slur the merits or to belittle the labors of other workers in the same field. The story of Morse's invention of the recording telegraph is told without rhetorical embellishment, but with the effectiveness of simple narrative. It was in the early part of October, 1832, and Morse was crossing the Atlantic on his way home from Europe, whither he had gone some three years before, to study the works of the great painters, for he was an artist before he turned his attention to telegraphy. One of his fellow travelers was Dr. Charles T. Jackson, of Boston, then profoundly interested in electro-magnetism, to which his attention had been directed by certain lectures which he had heard in Paris. In conversation with Morse he described in particular Ampère's brilliant experiments with the electro-magnet.

"The subject," writes Mr. Reid, "at once excited very general interest, into which Mr. Morse entered with awakened enthusiasm. Hitherto he had felt no other interest in electrical matters than that of a lively and excited curiosity. His early studies now enabled him to enter into the conversation with intelligent earnestness. Dr. Jackson had in his trunk, in the hold of the vessel, an electro-magnet, which he described, and during the conversation alluded to the length of wire in the coils. This led one of the company to inquire 'if the velocity of the electricity was retarded by the length of the wire.' A very pregnant thought lay in that inquiry, and the conversation became earnest and practical. Dr. Jackson replied that electricity passed instantaneously over any known length of wire. At this point Mr. Morse remarked, 'If the presence of electricity can be made visible in any part of the circuit, I see no reason why intelligence may not be transmitted instantaneously by electricity.'"

The author has had access to the artist's sketch-book, in which Morse at the time jotted down his alphabet scheme, and drew designs of various pieces of apparatus. These are reproduced in Mr. Reid's volume, and thus the reader is enabled to see Morse's system of telegraphy in its germ, so to speak. The author follows his own account of the "Birth of the Recording Telegraph," with the history of the invention composed by Morse himself in 1868, on the occasion of the International Exposition at Paris.

This "Morse Memorial" occupies the first one hundred pages of Mr. Reid's volume; the remainder is devoted to the "History of the Telegraph in America." The plan of this second part is an unfortunate one, comprising sketches of the rise and development of the different telegraph companies, with notices of their founders and promoters. This arrangement necessarily makes the work a congeries of mutually independent memoirs, each one valuable indeed in itself, but the effect of the whole must be to weary and confuse the reader's mind. Nevertheless, the work is one possessing permanent value, not as a "History," but rather as a collection of *mémoires pour servir*—of authentic materials which the philosophical historian will later digest and coördinate. It is safe to say that no future historian of the telegraph can afford to overlook the work done by Mr. Reid.

The book, in its mechanical execution, leaves nothing to be desired. It contains portraits, some in steel plate, others in

wood engraving, of many men of note connected with telegraphy in America, whether as inventors or as administrators.

Walks in London. By Augustus J. C. Hare. 2 vols. in one. New York: Routledge & Sons. 1878. Pp. 1,020.

"In these volumes," writes the author in the preface, "I believe all the objects of interest in London are described consecutively as they may be visited in excursions, taking Charing Cross as a center. The first volume is chiefly devoted to the city, the second to the West End and Westminster. . . . While endeavoring to make 'Walks in London' something more interesting than a guide-book, I have tried, especially in Westminster Abbey and the picture-galleries, to give such details as may suggest new lines of inquiry to those who care to linger and investigate."

Science Observer (Monthly). Volume II., No. 3. Boston: Amateur Scientific Society. Post-Office Box 2,725. Pp. 8. Subscription, 50 cents per year.

We observe with pleasure the continued success of this very meritorious little periodical. It appears to be particularly strong in the department of astronomy. The present number, for instance, has an elaborate article on "The Tides." This is the "leading article" of the number. The minor articles are on "The August Lyriads," "Mira Ceti," "Sun Spots," "The Intra-Mercurial Planet"; finally, we have "Ephemerides of Variable Stars."

Survey of the Northern and Northwestern Lakes and the Mississippi River, in charge of C. B. Comstock, Major of Engineers, and H. M. Adams, Captain of Engineers. With Charts. Washington: Government Printing-Office. 1877. Pp. 100.

The work of this survey, during the year ending June 1, 1877, may be thus summed up: On Lake Erie the triangulation has been carried from Westfield, New York, to near Painesville, Ohio; the topography and hydrography have been carried from Ashtabula, Ohio, to Vermilion, Ohio; the latitudes and longitudes of sundry points have been determined; a line of levels has been run between Escanaba and Marquette, to determine the difference of levels between Lakes Michigan and Superior; four charts of Lake Michigan, one of the St. Lawrence, and one of the Detroit River have been completed; the survey of the Mississippi has been carried from five miles above Cairo to a point eight miles above Columbus, Kentucky.

Geological and Natural History Survey of Minnesota (1877). With Maps. Minneapolis: Johnson, Smith & Harrison print. Pp. 225.

The first work undertaken by the officers connected with the Minnesota survey in the year 1877 was an attempt, and a successful one, to ascertain the causes of the foulness of the water in wells throughout the Red River Valley. It appears that, owing to the scarcity of building-stone in the valley, pine planks are used for curbing the wells, and to this cause is to be attributed the bad quality of the water, which in itself contains nothing that is unwholesome. Professor Winchell, State Geologist, with his associates, next examined localities in Wright County, where coal had been supposed to exist. At no point were Cretaceous beds seen *in situ*, though possibly they might be struck below the drift, in sinking a shaft. Preliminary reconnaissances were made into the counties of Goodhue and Morrison. The surveys of the following counties were completed, viz., Hennepin, Rock, Pipestone, and Rice.

The Minerals, Ores, Rocks, and Fossils in the Pacific Coast Exhibit at the Paris Exposition of 1878. San Francisco: Bosqui & Co. print. 1878. Pp. 99.

We have here a catalogue of the collection named above, preceded by an Introduction on the mineral resources of the Pacific States.

The Indian Question. Address by General Pope. Pp. 31.

The author proposes to locate reservations for Indians far in the rear of advancing emigration, in populous, well-ordered districts, where no hostility to the Indian is felt. Thus surrounded by good influences, the Indian might, the author thinks, become civilized, and perhaps eventually absorbed by the superior race.

PUBLICATIONS RECEIVED.

Cooking-School Text-Book. By Juliet Corson. New York: Orange Judd Co. Pp. 240.

Outline of General Geology. By Theo. B. Comstock. Ithaca, New York: University Press. Pp. 82.

Coal: its History and Uses. Edited by Professor Thorpe. London: Macmillan & Co. 1878. Pp. 350. $4.

Red Eagle. By G. C. Eggleston. New York: Dodd, Mead & Co. 1878. Pp. 346.

Elements of Comparative Anatomy. By Carl Gegenbaur. London: Macmillan & Co. 1878. Pp. 645. $7.

The Bride of Gettysburg. By J. D. Hylton. Palmyra, New Jersey. 1878. Pp. 172.

The Reign of God *not* "the Reign of Law." By Thomas Scott Bacon. Baltimore: Turnbull Brothers. 1878. Pp. 400. $1.50.

Political Economy. By William Roscher. New York: Holt & Co. 1878. Two vols., pp. 461 and 465. $7.

The Labor Side of the Great Sugar Question. New York. 1878. Pp. 30.

Researches in Telephony. By Professor Dolbear. From "Proceedings of the American Academy of Science and Arts." Pp. 15.

Report on Life-Saving Apparatus. By Lieutenant D. A. Lyle, of the Ordnance Department. Washington: Government Printing-Office. 1878. Pp. 100, with numerous Plates.

The Temperaments. By Dr. D. H. Jacques. New York: S. R. Wells. Pp. 239. $1.50.

Transmission of Power by Compressed Air. By R. Zahner. New York: Van Nostrand. Pp. 133. 50 cents.

Mansill's Almanac of Planetary Meteorology for 1879. Rock Island, Illinois: R. Crampton. Pp. 52. 50 cents.

Bulletin of the United States Geological and Geographical Survey of the Territories. Vol. IV., Nos. 2, 3, 4. Washington: Government Printing-Office. 1878.

Bulletin of the United States National Museum. Nos. 10 and 12. Washington: Government Printing-Office.

Bibliography of North American Invertebrate Paleontology. Pp. 119. Catalogue of Photographs of Indians. Pp. 122. Washington: Government Printing-Office.

Birds of the Colorado Valley. By Elliott Coues. Washington: Government Printing-Office. Pp. 822.

Drift from York Harbor. By G. Houghton. Boston: A. Williams & Co. 1879. Pp. 48.

Total Abstinence. By Dr. B. W. Richardson. London: Macmillan & Co. Pp 119.

Handbook of Alabama. By S. Berney. Pp. 338, with Map. Paper. $1.50.

Noxious and Beneficial Insects of Illinois. By Dr. C. Thomas. Springfield, Illinois: Lusk print. Pp. 290.

Reptiles and Batrachians of California, etc. By Dr. H. C. Yarrow. Pp. 23. Marine Fishes. By the same author. Pp. 7. Washington: Government Printing-Office.

Physiology of the Spermatozoa. By Dr. S. S. Herrick. Pp. 7.

Text-Books and Methods of Instruction in English. By J. M. Garnett. ("Educational Journal of Virginia.") Pp. 20.

Almanac for Use of Navigators for the Year 1879. Washington: Bureau of Navigation. Pp. 259. 50 cents.

Difficult Labor. By Dr. E. M. Hale. Pp. 91.

Native Wild Flowers and Ferns. By Thomas Meehan. Parts 13, 14, 15, 16. Boston: Prang & Co.

POPULAR MISCELLANY.

Reorganization of the Government Surveys.—We have already briefly stated the conclusions reached by the Committee of the National Academy of Sciences, appointed to consider what changes might be desired in the method of conducting the surveys of the Territories. We have since received an official copy of the Committee's report, and consider its subject matter of sufficient importance to justify a fuller abstract. The Committee interpreted the act of Congress directing their inquiry as applying only to surveys of the public domain, and hence did not take into consideration surveys or investigations which have for their objective point engineering works: such surveys, in the judgment of the Committee, should be conducted by the engineer corps of the army. The surveys which, in their opinion, were intended by the act to be inquired into were those popularly known as Wheeler's, Hayden's, Powell's, and the Land Surveys under the supervision of the Land-Office. Besides these, though not enumerated in the law, there is the Coast and Geodetic Survey. All the work done by these different corps may be classed under two heads: 1. Surveys of mensuration; 2. Surveys of geology and economic resources of the soil. The surveys of mensuration are at present conducted by five independent organizations, already named. There is no coördination between these five surveys, and their results show many contradictions. The geographical work of Wheeler's, or Hayden's, or Powell's survey is of little value for the parceling of land, while the land surveys are of correspondingly slight topographical and geographical value. The opinion of the Committee is, that "the Coast and Geodetic Survey is practically best prepared to execute the entire mensuration system required." But the Committee recommend that this survey be transferred from the Treasury to the Department of the Interior, and that in addition to its original field of work it should also assume the entire mensuration of the public domain.

The Geological Survey should have a separate organization. "To meet the requirements of existing laws in the disposition of the agricultural, mineral, pastoral, timber,

desert, and swamp lands, a thorough investigation and classification of acreage of the public domain are imperatively demanded. The Committee, therefore, recommends that Congress establish, under the Department of the Interior, an independent organization to be known as the United States Geological Survey, to be charged with the study of the geological structure and economic resources of the public domain." And the Committee recommends a discontinuance of the present Geographical and Geological Surveys and the present Land Surveys. "The effect of the above changes," says the Committee, "will be to maintain within the Interior Department three distinct organizatians: 1. The Coast and Interior Survey, whose function will embrace all questions of position and mensuration; 2. The United States Geological Survey, whose function will be the determination of all questions relating to the geological structure and natural resources of the public domain; 3. The Land-Office, controlling the disposition and sale of the public lands, including all questions of title and record. With this division should be secured a perfect coördination and coöperation between the three branches. The Land-Office should call upon the Coast and Interior Survey for all surveys and measurements required for the sale and disposition of land. The Land-Office should also call upon the United States Geological Survey for all information as to the value and classification of lands. The results of all the mensuration surveys, as soon as completed, should be immediately available for the Land-Office and for the Geological Survey, and for other branches of the Government as required. The Geological Survey should be authorized to execute local topographical surveys for special purposes, such, for instance, as the subterraneous surveys of mining districts and metallic deposits, etc."

Huxley on the Hand.—Professor Huxley chose for the subject of a recent lecture at the Workingmen's College, of which he is President, the human hand. He looked on the hand as not second in importance even to the brain itself. He pointed out the great diversity of operations for which man is dependent on the hand, and observed how it performs all its important functions by virtue of certain very simple facts in its form of construction. He referred to that famous work, Paley's "Natural Theology," and the argument which it enforces—that if a person were to find the whole machinery of a watch he must needs infer from the works of it that it *must have been intended* to serve a certain purpose. But Professor Huxley pointed out that, whatever the force of the argument of analogy in the case of the hand, it most assuredly does not apply in the sense in which it was used by Paley, because it can easily be shown that a man's hand was not put together in that way, but that it came about in quite a different manner. It was not a process in any way analogous to human means of construction, being, in fact, as different from the latter as the taking of a piece of iron and making it into an engine differs from taking it and letting it grow to an engine. This difference, he remarked, is highly important, as showing the danger of arguing from mere analogy—it shows that Paley's argument is not consonant with fact. Paley could not conceive that so complicated a structure as the human frame might, as a matter of fact, be developed or evolved by a purely natural operation.

Vehicles of Malaria.—Ague is commonly supposed to be due to the entrance into the system of a miasmatic organism. But no microscopist has ever seen this organism, neither can we account for the intermittency of the ague-paroxysms, nor can we say for certain through what medium it finds an entrance into the system. The majority of writers hold the opinion that *the air of marshes* is the sole cause of intermittent fever. But there exists strong evidence going to show that water, too, is a carrier of the poison. Take, for instance, two or three cases cited in the "Lancet"; and, first, the case recorded by Boudin, of three vessels sailing from Algiers to Marseilles, conveying eight hundred soldiers, who on shore had all been exposed to the same atmospheric conditions. Two of these vessels were supplied with good water, but the third with water from a marsh. The two former arrived at Marseilles without a sick man, but the third ship lost thirteen men, and had one hundred and twenty sick, nine-

ty-eight of whom were affected with malaria. Again, there is the outbreak of ague at Tilbury Fort in 1872, cited in Parkes's "Hygiene," where thirty-four men out of a garrison of one hundred and three were seized with ague, while the people at the railway station and the coast-guard men and their families just outside the fort entirely escaped. The troops had been supplied with water stored in tanks, collected from the rain-water of the roofs, while the people outside obtained theirs from a spring, the atmospheric conditions in both cases being identical.

The Werdermann Electric Light.—Mr. Edison's announcement of his success in solving the problem of adapting the electric light to domestic purposes has had the effect of bringing into public view a number of other contrivances for producing the same result. Among these, Werdermann's system appears to be perhaps the most promising; the following account of it we take from "Nature": "The principle of Werdermann's invention is that of keeping a small vertical pencil of carbon in contact with a large disk of the same material. In some earlier experiments he found that when he increased the sectional area of one carbon and reduced that of the other he produced an electrical light with the carbons in actual contact, a small arc appearing at the contact-point. The small carbon is a pencil three millimetres in diameter; the upper or negative carbon is a disk of two inches in diameter and an inch thick. The upper carbon is not consumed, so that the waste takes place only in the lower. In his lamp he places the disk uppermost with the pencil vertically beneath it, sliding up a metal tube which acts as a guide and contact. The pencil is kept in contact with the disk by means of chains attached to its lower extremity, passing over pulleys and down again to a counterweight of about one and a half pound. About three quarters of an inch of the lower carbon appears above the tube and is rendered incandescent by the passage of the current between it and the disk. This pencil is pointed, and retains its point all the time of burning. It is between this point and the disk that the small electric arc appears which gives the greater part of the light. In an exhibition of the system, ten lamps were shown in one circuit. The inventor believes that after further experiments he will be able to divide the current into fifty, one hundred, or even five hundred lights. Each lamp can be lighted and extinguished separately without affecting the others."

Dangers of Moldy Bread.—A singular case of poisoning from eating a pudding made in part of moldy bread is reported in the "Sanitary Record." The main facts of the case may be briefly stated as follows: The principal materials of the pudding consisted of scraps of bread left from making toast and sandwiches, and they had been about three weeks accumulating. To these scraps were added milk, eggs, sugar, currants, and nutmeg. The whole was baked in a very slow oven, and was subsequently eaten by the cook, the proprietor of the eating-house in which it was prepared, the children of the proprietor, and two other persons. All of these became violently ill, with symptoms of irritant poisoning. One of the children (aged three years) and one of the adults died. The necropsy of the body of the child caused the medical men to suspect poisoning, and accordingly the viscera, together with the remnant of the pudding, the materials used in making it, the matter vomited, etc., were sent to a chemical analyst, Mr. Alfred Allen, for examination. He made tests for several poisons, but without positive result. A puppy was fed with the pudding for two days without any poisonous effect. He was then led to look for ergot in the pudding, and was soon startled to find unquestionable evidence of its presence, as far as the chemical reactions went, though he was unable, with the aid of the microscope, to detect any actual ergot. From these facts Mr. Allen infers that the reactions hitherto supposed to be peculiar to ergot are common to other poisonous fungi.

Steering of Ocean-Steamers.—Among the reports of committees to the British Association at Dublin was one on the steering of screw-steamers. This report declares it to be an invariable rule that, during the interval in which a ship is stopping herself by

reversal of her screw, the rudder produces none of its usual effects to turn the ship. In fact, under these circumstances, the effect of the rudder is to turn the ship *in the opposite direction* from that in which she would turn if the screw were driving her ahead. A ship with screw reversed requires, in order to turn a circle, double the radius of that required while steaming ahead; and, if it is difficult to govern her direction, it is more difficult to predict what that direction will be. When moving at full speed a screw-steamer requires five lengths more or less in which to stop herself, whereas by using her rudder and steaming on at full speed ahead she would be able to turn herself through a quadrant without having advanced five lengths in her original direction. Moral: When collision is imminent, steam ahead and be quick with the rudder. But, owing to the imperfection of the steering-apparatus now generally employed, quickness is impossible, and it takes a long time to put a large angle on the rudder. "The result is" (so say the Committee) "that it is often one or two minutes after the order is heard by the men at the wheel before there is any large angle on the rudder, and of course, under these circumstances, it is absurd to talk of making use of the turning qualities of a ship in case of emergency. The power available to turn the rudder should be proportional to the tonnage of the vessel, and there is no mechanical reason why the rudder of the largest vessel should not be brought hard over in less than fifteen seconds from the time the order is given. Had those in charge of steamships efficient control over their rudders, it is probable that much less would be heard of the reversing of the engines in cases of imminent danger." Clearly this is a question which calls imperatively for regulation by the Admiralty or some other competent authority.

The Candle-Fish.—The eulachon, or candle-fish (*Thaleichthys pacificus*), an inhabitant of the Pacific Ocean in the vicinity of British Columbia and northward, is worthy of a place among the curiosities of the animal kingdom. It is a small fish—about fourteen inches in length—and in appearance resembles a smelt. It is the fattest of all known fishes; and, in fact, the Indians use it, in the dried state, as a candle. On touching the tail to the fire it burns with a bright flame till the whole is consumed; more usually, however, a wick of woody fiber is passed through the body of the fish from end to end to insure continuous combustion. But the candle-fish is also employed as an article of food, and in spite of its fatness—indeed, *on account* of its fatness—is highly esteemed by the Indians as a warming food for winter. For this purpose they are dried and smoked in the spring, and then packed away. So preserved they are eaten whole, or the oil is tried out and eaten as butter. The take is usually very large, and only a small portion is dried and smoked. The remainder are piled in heaps till partial decomposition has set in; they are then packed in large boxes and the oil pressed out. This oil also is used as food, and it is said to be not altogether intolerable to the stomach of civilized man. The appearance of the first shoal of candle-fish in March is greeted by the Indians with extravagant demonstrations of joy. It is their Easter.

The Storage and Purification of Water.—In one of a series of papers on "Water-Supply for Small Towns," now publishing in "The Plumber and Sanitary Engineer," Mr. E. S. Philbrick has some remarks on the best material for constructing cisterns. He gives the preference to brick, as being sufficiently durable, and at the same time cheap. As brickwork is not adapted to resist tensile strains, brick cisterns, if of any considerable size, can not withstand water-pressure, by the strength of walls alone. So we put them underground, getting the earth-pressure from without to balance the water-pressure from within, and at the same time protect them from frost. The circular form generally used is strong enough in itself to resist the earth-pressure when the tank is empty, for this is a compressive force. The extended application of hydraulic cement thus enables us to construct, in almost any part of the world where commercial relations exist, an imperishable and incorruptible water-tank, so far as its own materials go.

But cistern-water will always be more or less contaminated by the accumulation of dust swept down from the roof. Hence a cistern should be thoroughly cleaned from

time to time as occasion may require. Every cistern intended to hold water for drinking should have a filter. For this purpose a chamber can be parted off on one side the cistern, within which the suction-pipe takes the water for use, and the filtering material placed so as to pass the water through holes in this partition. Sometimes soft or half-burned bricks are used for this partition, through the pores of which the water passes freely, if sufficient surface be used. If, however, it be desired to remove any dissolved impurities from the water, these mechanical filters, whether brick, gravel, sand, or sponge, are useless, and recourse must be had to a charcoal or spongy iron filter, which acts chemically upon various substances in solution, burning them up, as it were, by the oxygen within the filter.

These filters, however, require such frequent cleansing for the renewal of their efficiency, that they can only be used effectively in a portable form, and cannot therefore be built into the tank.

Products of Coal-Gas Combustion.—From a lecture by Mr. Thomas Mills, before the British Association of Gas Managers, we take the following remarks on the products of combustion of coal-gas: "Of such gas, supposing its specific gravity to be ·5, or half that of air, a cubic foot contains about half its own weight of carbon; and, if this cubic foot of gas be burned, it will give a little more than half a cubic foot of carbonic acid, or, in weight, 488 grains. Again, a cubic foot of coal-gas, of ·5 specific gravity, contains about 41 grains of hydrogen, and this hydrogen in burning will produce 372 grains of water. If we regard the quantity of air necessary to supply the requisite quantity of oxygen to a cubic foot of gas, it lies between five and six feet of air. For every cubic foot of gas burned we require the oxygen of between five and six cubic feet of air, and this will give half a cubic foot of carbonic acid as a result. When we come to estimate the total products of gas-combustion in such a place as London, the figures are really startling. The quantity of gas consumed in London annually may be taken approximately at about 15,000,000 cubic feet. The amount of carbonic acid given off during a year by the combustion of these 15,000,000 of cubic feet is 433,000 tons. The amount of water produced by the combustion of this quantity of coal-gas is 360,000 tons, or 80,000,000 gallons. One of the largest, if not the largest gasholder-tanks in London, is at the Phœnix Works at Kennington. That gasholder-tank, supposing it had no internal cone, and were perfectly flat at the bottom, would hold 10,000,000 gallons of water, if filled to the brim. You might empty that tank and fill it eight times over in a year with the water produced by the burning of the coal-gas consumed in the metropolis during that time."

How the Penguin rears its Young.—In the southern part of the Indian Ocean—about latitude 40° south, longitude 80° east, or about half-way between Africa and Australia—are the two islands, St. Paul and Amsterdam, both of recent volcanic origin, and both the favorite resort of the albatross. But they are most of all remarkable for the number of penguins which have here their permanent residence. According to a writer in *Chambers's Journal*, these penguins form a rude sort of commonwealth among themselves. In the rearing of their young they exhibit considerable dependence on one another. The hens lay one or two eggs, never more, in a hollow of the ground or on a little grass. The task of incubation is performed by both parents, the one "off duty" going to the sea to procure food for itself, and when the young are hatched bringing a supply for the family. "Where tens of thousands of nests are collected together so closely that the visitor cannot walk without demolishing new-born nestlings or eggs at almost every step, it is difficult to understand how each bird knows its own nest, eggs, or nestling, as it appears to be the case until the young are able to walk about for themselves. Then the latter form into 'infant schools,' presided over by several matrons, and ask and receive food from any charitable passer-by, and the social system, so far as it goes, has attained its highest point. There is no longer any recognition of *meum* and *tuum*, but a determination on the part of each adult to do the best for the rising generation, without regard to the petty rights of property so

stoutly maintained and hotly contested in the egg stage. Woe betide the incautious or over-confident experimenter who shall remove one of these fierce motherly things from her nest with his hands!—the penalty will be a succession of stabs, which produce notoriously painful wounds. But the occupant of the nearest nest will always receive and tuck under her, together with her own brood, the young of a dispossessed neighbor. All through the nursery are well-beaten paths along which the birds hop in single file with most grotesque action to and from the sea; and from the nests on either side come sharp stabs at the legs of the intruder, a deafening roar accompanying his progress the while, and an odor assaulting his nose which only those who have sailed in a guano-ship can realize. The time has now arrived when the young must be taught their first swimming-lessons, and the rudiments of that aquatic life to which their special structure confines them. From the rookery to the sea they advance, hopping with both legs together, and jump feet foremost bolt upright from a ledge into the water. Then, and only then, are they thoroughly at home, and, making use of nothing but the powerful scaly flippers, dart about with the rapidity of a fish. Frequently the old bird will rise to the surface with a young one balanced on each flipper, maintained in its precarious position by the grasp of its own tiny paddles, and no doubt vastly enjoying this introduction to life and the novel experiences to be met with under water."

A Unique Surgical Operation. — A surgical operation of probably unique character is described in the *Lancet*, by Dr. Alexander Patterson—namely, the employment of a piece of dog's bone in the treatment of ununited fracture. The patient, while at sea, sustained a simple fracture of both bones of the left forearm. The arm was at once put in splints, and so remained for some weeks. On removing the splints it was found that the bones had not united. It was not till eight months after the occurrence of the accident that the man was admitted to the Western Infirmary of Glasgow. Repeated efforts were made to induce the broken bones to reunite, but all without avail; and finally it was decided to amputate the arm. In the absence of the regular surgeon, Dr. Patterson took charge of the case, and obtained permission to make an attempt at saving the limb. The operation is best described in the author's own words:

"The patient was taken and placed under the influence of chloroform, while at the same time a retriever dog was being anæsthetized. I made an incision along the ulnar side of the arm, cutting down upon the ends of the fractured bone, and removing the fibrous band which alone formed the bond of union; the rounded points were removed by the saw, and a hole drilled obliquely through each squared end. The same process was repeated on the radial side, when it was found that an interspace of about three-quarters of an inch existed between the two fragments of the radius. In the mean time, one of the senior students had exposed the humerus of the quadruped, completely denuded of every tissue except the periosteum. The length of bone was accurately measured (three-quarters of an inch), while from half an inch beyond the end of the necessary length the periosteal covering was rapidly but carefully dissected, the bone sawed through, a hole drilled in either end obliquely, as in the radius and ulna, and at once placed between the ends of the radius, where it fitted accurately. Wires having been passed through the holes, the bones were firmly tied together, the loose half-inch margin of the periosteum of the foreign bone being carefully spread over the periosteum of the radius. The wound was stitched with silver wire, the bone sutures coming out at each end of the incision. Wires were passed through the ulna, tied together, and the wound treated in a similar manner. The entire operation was conducted under the carbolic-acid spray. The arm was put up in gauze, and held in two rectangular splints."

We need not give details of the patient's condition from day to day. Suffice it to say that one wound remained open for twelve months, and that then the dog's bone, reduced to about half its size, came away, after which the wound healed completely. The radius seemed to have fallen in somewhat toward the ulna, leaving a slight deformity. The man is by occupation a ma-

rine engineer, and is now able to resume his ordinary pursuits. Dr. Patterson had hoped that the strange bone might find a new home for itself in the human arm. This failing, he was confident that it would secure perfect alignment and steadiness in the ulnar fragments. In the latter respect the event fully justified his anticipation. He still believes in the possibility of incorporating a foreign bone.

Ancient Hygiene.—It would be matter for a very interesting inquiry to ascertain how it happens that, with regard to many abstruse questions of practical science, hygiene for instance, the ancient Hebrews, Romans, Greeks, etc., reached results which for correctness put to shame the ignorance of later times. An illustration of this truth is given in a memoir by Dr. John Spear, lately published in the "Lancet." He first speaks of the precautions to be taken in selecting sites for human habitations. From the "Mishna" we learn how carefully all unclean things were removed from the vicinity of Jerusalem and the temple; and the investigations of Signor Perotti in the site of the ancient Jewish capital have shown how complete were the systems of sewers and the means of sewage precipitation and disposal. We find again that the Latin author Vitruvius, in his work "De Architectura," supposed to have been written in the reign of Augustus, in giving directions for securing healthy sites for towns, lays special stress on the necessity of a porous soil, and, in order to secure the ventilation of that soil, on perfect subsoil drainage. The views of Hippocrates on this subject, as also of Pliny and of other classic writers, might be studied at the present day with profit. Thus it would appear that the memorable researches of Pettenkofer, in a great measure, serve only to make us acquainted with the laws which were perfectly well known to the men of olden time. Then, as to practice: in the ancient cities of the world—Rome, Carthage, Herculaneum, Nineveh, and Alexandria, we know how well pollution of the soil was guarded against. What most judiciously executed works for this and other sanitary objects existed, recent discoveries have revealed. Probably in all these places too, and certainly in Rome, interment within the city walls was forbidden. "It is worthy of note," observes Dr. Spear, "that at this period of history pestilences and epidemics were not of common occurrence, and when they appeared they were usually clearly traceable to famine or to war. But to this enlightened and golden age succeeded one of darkness and intellectual torpor. Sanitary measures were forgotten or ignored; filth accumulated in crowded towns; the practice of intramural sepulture became general. The soil, the air, the water, we read, were impregnated with decomposing matters. As a result we have recorded those most destructive pestilences of the middle ages. The plague, the black-death, fever, and small-pox, swept over the land. . . . Pestilences were ascribed to the pleasure of Almighty God."

How to keep cool.—The experiences of an English visitor to the Paris World's Fair, as recorded in the "English Mechanic," convey a useful lesson on the means of enduring without serious discomfort the extreme of summer heat. This gentleman, Mr. D. Winstanley, writes that he went to Paris in March, the weather then being decidedly cold. As the temperature gradually increased he noticed that his ordinary clothing became uncomfortable whenever at 8 A. M. the thermometer indicated 70° Fahr. Accordingly, when that temperature was indicated, he made it a rule to adopt linen clothing, and he then enjoyed a comfortable temperature throughout the day. As summer advanced and the heat increased he never felt hot when clad in linen. Even when the thermometer had risen to 97° Fahr. in the shade, he felt no uncomfortable sensation of being hot, and, furnished with a "havelock," strolled leisurely in the blazing sun for hours, the thermometer indicating 125° Fahr., without discomfort, and without consciousness of perspiration. Mr. Winstanley adds, however, that during the hot weather he lived almost wholly on vegetables and fruits—peas, beans, melons, etc. —using no meat, and above all no fat. He takes occasion to commend the French style of windows in dwelling-houses. "Instead of our miserable idea of an horizontal section," he writes, "which permits at most only one-half of the window aperture to be

opened for the admission of air, the French employ the vertical division, and open the windows inwardly on hinges as we open doors. The window apertures are also large, or rather high, descending to within eighteen inches of the floor, and ascending to within four inches of the ceiling. Outside these are latticed shutters. When the windows are open and the shutters closed the sun is effectually kept out, and the free circulation of the air is scarcely interfered with. A light balustrade of iron, within the shutters and without the glass, serves to prevent falling through the windows."

Destruction of American Forests.—It has been for some years apparent that the United States supply of timber must fail at no distant day, unless some concerted measures are taken for growing new forests or in some way preserving the old. The present condition of the lumbering business will be understood from the following facts, published by the St. Paul "Pioneer Press," and based on the observations of Mr. James Little, a lumber-merchant of Montreal, who has long studied this subject: Of the twenty-six States comprising the New England, Middle, Western, and Northwestern, to the Rocky Mountains, only four are now able to furnish lumber-supplies beyond their own requirements; the four being Maine, Michigan, Minnesota, and Wisconsin. But Maine is almost stripped of her pine-forests, and lumberers have to go to the head-waters of the rivers in search of spruce, while mere saplings, six or seven inches in diameter, go to the mill. In a few years Maine will have neither pine nor spruce for home consumption. The northern parts of Michigan, Wisconsin, and Minnesota, are the only localities of the whole twenty-six States which can furnish supplies of white pine beyond the home demand; but they will not be able to do so, Mr. Little affirms, for more than five or six years longer. The main streams are all stripped, and the dependence of the lumbermen is now on the head-waters of the tributaries. In 1870, according to the census report, there were in the United States 173,450 industrial establishments, employing 1,093,202 hands, devoted to the manufacture of wooden articles. The impression prevails that when our supply of lumber fails, as it must inevitably within the next ten years, we can find in Canada a supply that will not be exhausted in centuries. But this is an error; at least, Mr. Little asserts that there is not from Manitoba to the Gulf of St. Lawrence as much pine, spruce, hemlock, white-wood, and other commercial timber, as would supply the United States for even three years! In the light of such facts as these, it behooves the people of this country to seriously consider the subject of reforestation and the protection of young timber-trees.

Movement of Water in the Suez Canal.—The currents of the Suez Canal and the action of the prevalent winds on the water therein have been studied by M. Lemasson, who finds that Lake Timsah and the basin of the Bitter Lakes, the former in the middle of the line of navigation, the latter nearly at the middle of the southern branch of the canal, constitute two great regulators, at which the tidal currents from the two seas respectively expire. The north and south branches of the canal are not, however, independent as regards the movement of their waters. The dominant winds in this region blow, from May to October, from the north and northwest, and raise the mean level of the waters of the Mediterranean at Port Saïd, while they depress the mean level at Suez. The difference of level, which attains almost sixteen inches in September, sets up, in summer, a current from the Mediterranean to the Red Sea, which is interrupted by the tides, but nevertheless carries a considerable volume of water from north to south. In the winter, on the contrary, the south winds blow strongly, and the mean level of the Red Sea is then higher than that of the Mediterranean, the difference attaining a maximum of nearly one foot. The general direction of the current of the canal then sets from the Red Sea to the Mediterranean. The volume of water flowing annually from sea to sea is estimated at 400,000,000 cubic metres, and this with the tidal currents annihilates the effects of evaporation at the surface of the lakes, and aids the solution of the great salt deposit in the basin of the Bitter Lakes, which, instead of increasing, is diminishing, especially in the line of transit of ships.

The Parasites in Pork.—*Cysticercus cellulosæ*, familiarly known as "measles" in pork, on passing into the human economy may develop into the common tapeworm. Analogous entozoa are sometimes found in beef, veal, mutton, and other meats, but the great source of these formidable parasites is pork. They can be easily detected in the carcass of a pig that is infested by them. "They are in the muscles," writes Dr. Vacher, in a paper read before an association of health officers, "between the fibers, between the muscles, on the surface of the muscles, and even in the walls of the heart. . . . Specimens from the same beast," he continues, "are nearly of the same size, but specimens taken from different beasts vary considerably in size. The egg-shaped investing bladder is scarcely ever less than an eighth of an inch in length, and it sometimes measures half an inch, so that it may be easily seen and removed. It is semi-transparent, and contains a clear fluid, and what looks like a little white ball. On transferring the bladder to a glass slip, a touch with the point of a knife will suffice to rupture it, and if you then press a cover down upon it you have a preparation in which the *rostellum* and circlet of hooks may be distinctly seen with an ordinary lens." When meat is a little dry from exposure to air the cysts collapse, and are not distinctly visible. Dr. Thudicum recommends that such pork be submerged in water which the cysts will absorb by endosmosis.

Proposed Domestication of the African Elephant.—While the Asiatic elephant is in India domesticated and employed as a beast of burden, the African elephant, living, has no economic use, and is merely hunted for "sport," or for its tusks, hide, and flesh. It is now proposed to attempt the utilization of the African elephant as an aid in the exploration of the "Dark Continent" and for the transportation of goods from the coast to the fertile plateaus of the interior. Even in the Cape Colony, to say nothing of central Africa, elephants are numerous, and one troop has been observed within fifty miles of Port Elizabeth. Sir J. Fayrer suggests that on this troop the attempt at domestication might first be made. According to him, the African elephant is as well fitted for labor as the Asiatic, and could be as easily tamed and trained. That this is the case is amply proved by the state of docility to which the male and female African elephants in the London Zoölogical Garden have been reduced by their keeper. They are just as obedient, intelligent, and free from vice as their Asiatic congeners, and there appears to be no room for doubt that they might be utilized to just as good purpose. The importation of a few of the officers who have had experience in catching and training elephants in India, together with a few trained Indian elephants to commence the work, would very soon put the value of the project to the test.

Relation of Brain-bulk to Intelligence.—From observations made on numerous series of human crania, Dr. Lebon, of Paris, infers that intelligence is in proportion to the volume of the cranium. By comparing these series of crania, it is also found that the superior races present a much greater number of voluminous crania than the others. The same phenomenon is presented in proportion to the degree of civilization; the Parisian crania of the twelfth century present, for example, a less volume than the crania of modern Parisians; at the same time the difference between individuals becomes more considerable. Dr. Lebon does not believe that stature exercises any considerable influence on the volume of the cranium and the weight of the brain. Nevertheless, with equal height, the woman has a brain less heavy than the man. The author, from a study of seventeen male and seventeen female brains, found between them a difference of 172 grammes to the advantage of the former. It is worthy of remark that, among the superior races, the cranium of the women is generally much less than among the inferior races. This is due, Dr. Lebon says, to the insignificant part taken by woman in the work of modern society. There is a constant inequality of development between the two halves of the brain, which is sometimes more developed on the right, sometimes on the left, without race or state of intelligence appearing to have any manifest influence on the direction of this inequality of development.

NOTES.

In the death of George Henry Lewes, which occurred in London, December 1st, the more serious literature of England lost one of its best representatives. Mr. Lewes possessed a very remarkable degree of native intellectual power, and this gift of nature he appears to have turned to the best account by stern self-discipline and assiduous and well-regulated study. He was a worker in many different fields of literary activity, in some of which he proved himself a master, while in none did he sink to mediocrity. His learning was profound and accurate, and his control of his intellectual resources was complete. In our ninth volume we published a brief biography of Mr. Lewes, with portrait. He has since that period been engaged on the "Problems of Life and Mind," but, as far as we know, has not published any volume since the second.

An Englishman traveling in the Rocky Mountains, in company with an American astronomer, severely criticised the hideous defacement of picturesque places by big-lettered advertisements on every conspicuous rock. His fellow traveler readily admitted that the custom admits of no justification, but added, "I guess we are not as bad as some of your people who have tried to advertise themselves on the planet Mars" (by naming Martial objects after themselves or their friends).

A new illuminating gas is now, according to the Liverpool "Post," under examination by the British Lighthouse Board (Trinity House). It is declared to be not only cheaper than ordinary gas, but far more effective. It is capable of so much concentration that the quantity contained in a small buoy has supplied a light burning for twenty-eight days with sufficient brilliancy to show the position of the buoy to passing ships.

Dr. Lyon Playfair complains that, whereas the 30,000 medical men of England are protected by law against the competition of unqualified practitioners, the 150,000 teachers have no such protection, and have no recognition in the face of the law as constituting a distinct profession. Any one who has failed in any other calling may, if he please, open a school or seminary, and no one can question his right. Dr. Playfair intends to move in Parliament for a bill to determine the qualifications of teachers, and to exclude from that profession all but duly registered aspirants.

The gas-wells of East Liverpool, Ohio, are worthy of being ranked among the "wonders of the world." They are situated, writes a correspondent of the Cleveland "Herald," in and around the town, and give it a continual supply of light, the gas being almost as free as air. It costs practically nothing, and both heats and lights the town. The street lamps are ablaze day as well as night, for it costs nothing to supply the gas, and it takes trouble to shut it off. Then the gas is almost the only fuel employed in the town, being conducted into the grates and stoves by pipes. It is also used for generating steam-power for sundry great pottery manufactories, employing upward of 2,000 workmen. The first of the wells was opened twenty years ago, and there are no signs of exhaustion.

In the discussion of the profits of wheat-growing to-day as compared with the profits forty or fifty years ago—a discussion suggested by a strike of agricultural laborers in an English county—the very curious fact was brought out that the wheat itself represents only one half of the produce, the other half being represented by the straw. The price of wheat has been declining for years, but the price of straw has been rising, till now it is actually the more important, in England, that is to say. The demand for straw as litter, for fodder to mix with other foods, and for different branches of manufacturing industry, has so increased that the article is scarce even in rural districts.

A writer in "Land and Water," under the signature of "Bangkok," gives this amusing account of a little scene which he witnessed at the court of the "Second King" of Siam: "After sitting down and lighting our cigarettes he (the Second King) rang a little hand-bell, and in the dimly-lighted veranda I saw three figures wriggling along on their stomachs to his majesty's chair, on reaching which they sat up on their haunches and showed themselves, three handsome white-haired old men who were introduced to me as the royal astronomers." They had been summoned for the purpose of exhibiting to the foreigner their calculations of an approaching solar eclipse, which proved to be very nearly exact. After a little present from their master, the old gentlemen retired as they had come.

The "Holy Synod" of Athens having ordered public prayer for rain to be made in all the churches of its jurisdiction, one priest, according to the "Independent," made the following common-sense remarks to his congregation: "Blessed Christians," said he, "our most holy synod has ordered public prayer to be made for rain. But I have been considering that, although we in Attica do indeed need rain, in Peloponnesus it would be fatal to the olives and currants. Therefore, blessed Christians, I leave the matter to each one of you. As for me, I am quite willing to leave it to God to do as he chooses."

CHRISTIAN GOTTFRIED EHRENBERG.

THE

POPULAR SCIENCE MONTHLY.

MARCH, 1879.

THE ELECTRIC LIGHT.[1]

By Professor JOHN TYNDALL.

THE subject of this evening's discourse was proposed by our late honorary secretary.[2] That word "late" has for me its own connotations. It implies, among other things, the loss of a comrade by whose side I have worked for thirteen years. On the other hand, regret is not without its opposite in the feeling with which I have seen him rise by sheer intrinsic merit, moral and intellectual, to the highest official position which it is in the power of English science to bestow. Well, he, whose constant desire and practice were to promote the interests and extend the usefulness of this institution, thought that, at a time when the electric light occupied so much of public attention, a few sound notions regarding it, on the more purely scientific side, might, to use his own pithy expression, be "planted" in the public mind. I am here to-night with the view of trying, to the best of my ability, to realize the idea of our friend.

In the year 1800 Volta announced his immortal discovery of the pile. Whetted to eagerness by the previous conflict between him and Galvani, the scientific men of the age flung themselves with ardor upon the new discovery, repeating Volta's experiments, and extending them in many ways. The light and heat of the voltaic circuit attracted marked attention, and in the innumerable tests and trials to which this question was subjected, the utility of platinum and charcoal as means of exalting the light was on all hands recognized. Mr. Children, with a battery surpassing in strength all its predecessors, fused platinum wires eighteen inches long, while "points of charcoal produced a light

[1] A discourse delivered at the Royal Institution of Great Britain on Friday, January 17, 1879.

[2] Mr. William Spottiswoode, now President of the Royal Society.

so vivid that the sunshine, compared with it, appeared feeble."[1] Such effects reached their culmination when, in 1808, through the liberality of a few members of the Royal Institution, Davy was enabled to construct a battery of two thousand pairs of plates, with which he afterward obtained calorific and luminous effects far transcending anything previously observed. The arc of flame between the carbon terminals was four inches long, and by its heat quartz, sapphire, magnesia, and lime were melted like wax in a candle-flame; while fragments of diamond and plumbago rapidly disappeared, as if reduced to vapor.[2]

The first condition to be fulfilled in the development of heat and light by the electric current is that it shall encounter and overcome resistance. Flowing through a perfect conductor, no matter what the strength of the current might be, neither heat nor light could be developed. A rod of unresisting copper carries away uninjured and unwarmed an atmospheric discharge competent to shiver to splinters a resisting oak. I send the self-same current through a wire composed of alternate lengths of silver and platinum. The silver offers little resistance, the platinum offers much. The consequence is that the platinum is raised to a white heat, while the silver is not visibly warmed. The same holds good with regard to the carbon terminals employed for the production of the electric light. The interval between them offers a powerful resistance to the passage of the current, and it is by the gathering up of the force necessary to burst across this interval that the voltaic current is able to throw the carbon into that state of violent intestine commotion which we call heat, and to which its effulgence is due. The smallest interval of air usually suffices to stop the current. But when the carbon points are first brought together and then separated, there occurs between them a discharge of incandescent matter which carries, or may carry, the current over a considerable space. The light comes almost wholly from the incandescent carbons. The space between them is filled with a blue flame which, being usually bent by the earth's magnetism, receives the name of the Voltaic Arc.

For seventy years, then, we have been in possession of this transcendent light without applying it to the illumination of our streets and houses. Such applications suggested themselves at the outset, but there were grave difficulties in their way. The first difficulty arose from the waste of the carbons, which are dissipated in part by ordinary combustion, and in part by the electric transfer of matter from the one carbon to the other. To keep the carbons at the proper distance asunder, regulators were devised—the earliest, I believe, by Staite, and

[1] Davy, "Chemical Philosophy," p. 110.

[2] In the concluding lecture at the Royal Institution in June, 1810, Davy showed the action of this battery. He then fused iridium, the alloy of iridium and osmium, and other refractory substances. See "Philosophical Magazine," vol. xxxv., p. 463. Quetelet assigns the first production of the spark between coal-points to Curtet in 1802. Davy certainly in that year showed the carbon-light with a battery of 150 pairs of plates in the theatre of the Royal Institution ("Journal of the Royal Institution," vol. i., p. 166).

the most successful by Duboscq, Foucault, and Serrin, who have been succeeded by Holmes, Siemens, Browning, Carré, Gramme, Lontin, and others. By such arrangements the first difficulty was practically overcome ; but the second, a graver one, is probably inseparable from the construction of the voltaic battery. It arises from the operation of that inexorable law which, throughout the material universe, demands an eye for an eye and a tooth for a tooth, refusing to yield the faintest glow of heat or glimmer of light without the expenditure of an absolutely equal quantity of some other power. Hence, in practice, the desirability of any transformation must depend upon the value of the product in relation to that of the power expended. The metal zinc can be burned like paper ; it might be ignited in a flame, but it is possible to avoid the introduction of all foreign heat and to burn the zinc in air of the temperature of this room. This is done by placing zinc-foil at the focus of a concave mirror, which concentrates to a point the divergent electric beam, but which does not warm the air. The zinc burns at the focus with a violet flame, and we could readily determine the amount of heat generated by its combustion. But zinc can be burned not only in air but in liquids. It is thus burned when acidulated water is poured over it; it is also thus burned in the voltaic battery. Here, however, to obtain the oxygen necessary for its combustion, the zinc has to dislodge the hydrogen with which the oxygen is combined. The consequence is, that the heat due to the combustion of the metal in the liquid falls short of that developed by its combustion in air, by the exact quantity necessary to separate the oxygen from the hydrogen. Fully four fifths of the total heat is used up in this molecular work, only one fifth remaining to warm the battery. It is upon this residue that we must now fix our attention, for it is solely out of it that we manufacture our electric light.

Before you are two small voltaic batteries of ten cells each. The two ends of one of them are united by a thick copper wire, while into the circuit of the other a thin platinum wire is introduced. The platinum glows with a white heat, while the copper wire is not sensibly warmed. Now an ounce of zinc, like an ounce of coal, produces by its complete combustion in air a constant quantity of heat. The total heat developed by an ounce of zinc through its union with oxygen in the battery is also absolutely invariable. Let our two batteries, then, continue in action until an ounce of zinc in each of them is consumed. In the one case the heat generated is purely domestic, being liberated on the hearth where the fuel is burned, that is to say in the cells of the battery itself. In the other case, the heat is in part domestic and in part foreign—in part within the battery and in part outside. One of the fundamental truths to be borne in mind is that the sum of the foreign and domestic—of the external and internal—heats is fixed and invariable. Hence, to have heat outside you must draw upon the heat within. These remarks apply to the electric light. By the intermediation of the

electric current the moderate warmth of the battery is not only carried away but concentrated, so as to produce, at any distance from its origin, a heat next in order to that of the sun. The current might therefore be defined as the swift carrier of heat. Loading itself here with invisible power, by a process of transmutation which outstrips the dreams of the alchemist, it can discharge its load, in the fraction of a second, as light and heat, at the opposite side of the world.

Thus, the light and heat produced outside the battery are derived from the metallic fuel burned within the battery; and, as zinc happens to be an expensive fuel, though we have possessed the electric light for more than seventy years, it has been too costly to come into general use. But within these walls, in the autumn of 1831, Faraday discovered a new source of electricity, which we have now to investigate. On the table before me lies a coil of covered copper wire, with its ends disunited. I lift one side of the coil from the table, and in doing so exert the muscular effort necessary to overcome the simple weight of the coil. I unite its two ends and repeat the experiment. The effort now required, if accurately measured, would be found greater than before. In lifting the coil I cut the lines of the earth's magnetic force, such cutting, as proved by Faraday, being always accompanied, in a closed conductor, by the production of an "induced" electric current which, as long as the ends of the coil remained separate, had no circuit through which it could pass. The current here evoked subsides immediately as heat; this heat being the exact equivalent of the excess of effort just referred to as over and above that necessary to overcome the simple weight of the coil. When the coil is liberated it falls back to the table, and when its ends are united it encounters a resistance over and above that of the air. It generates an electric current opposed in direction to the first, and reaches the table with a diminished shock. The amount of the diminution is accurately represented by the warmth which the momentary current develops in the coil. Various devices were employed to exalt these induced currents, among which the instruments of Pixii, Clarke, and Saxton were long conspicuous. Faraday, indeed, foresaw that such attempts were sure to be made; but he chose to leave them in the hands of the mechanician, while he himself pursued the deeper study of facts and principles. "I have rather," he writes in 1831, "been desirous of discovering new facts and new relations dependent on magneto-electric induction than of exalting the force of those already obtained; being assured that the latter would find their full development hereafter."

For more than twenty years magneto-electricity had subserved its first and noblest purpose of augmenting our knowledge of the powers of nature. It had been discovered and applied to intellectual ends, its application to practical ends being still unrealized. The Drummond light had raised thoughts and hopes of vast improvements in public illumination. Many inventors tried to obtain it cheaply; and in

1853 an attempt was made to organize a company in Paris for the purpose of procuring, through the decomposition of water by a powerful magneto-electric machine constructed by M. Nollet, the oxygen and hydrogen necessary for the lime-light. The experiment failed, but the apparatus by which it was attempted suggested to Mr. Holmes other and more hopeful applications. Abandoning the attempt to produce the lime-light, with persevering skill Holmes continued to improve the apparatus and to augment its power, until it was finally able to yield a magneto-electric light comparable to that of the voltaic battery. Judged by later knowledge, this first machine would be considered cumbrous and defective in the extreme; but, judged by the light of antecedent events, it marked a great step forward.

Faraday was profoundly interested in the growth of his own discovery. The Elder Brethren of the Trinity House had had the wisdom to make him their "Scientific Adviser"; and it is interesting to notice, in his reports regarding the light, the mixture of enthusiasm and caution which characterized him. Enthusiasm was with him a motive power, guided and controlled by a disciplined judgment. He rode it as a charger, holding it in by a strong rein. While dealing with Holmes, he states the case of the light *pro* and *con*. He checks the ardor of the inventor, and, as regards cost, rejecting sanguine estimates, he insists over and over again on the necessity of continued experiment for the solution of this important question. His matured opinion was, however, strongly in favor of the light. "I beg to state," he writes in his report to the Elder Brethren, "that, in my opinion, Professor Holmes has practically established the fitness and sufficiency of the magneto-electric light for lighthouse purposes, so far as its nature and management are concerned. The light produced is powerful beyond any other that I have yet seen so applied, and in principle may be accumulated to any degree; its regularity in the lantern is great; its management easy, and its care there may be confided to attentive keepers of the ordinary degree of intellect and knowledge." As regards the conduct of Professor Holmes during these memorable experiments, it is only fair to add the following remark with which Faraday closes the report submitted to the Elder Brethren of the Trinity House on the 29th of April, 1859: "I must bear my testimony," he says, "to the perfect openness, candor, and honor of Professor Holmes. He has answered every question, concealed no weak point, explained every applied principle, given every reason for a change either in this or that direction, during several periods of close questioning, in a manner that was very agreeable to me, whose duty it was to search for real faults or possible objections in respect both of the present time and the future."[1]

Soon afterward the Elder Brethren of the Trinity House had the intelligent courage to establish the machines of Holmes permanently at

[1] Holmes's first offer of his machine to the Trinity House bears the date February 2, 1857.

Dungeness, where the magneto-electric light continued to shine for many years.

The magneto-electric machine of the Alliance Company soon succeeded that of Holmes, and was in various ways a very marked improvement on the latter. Its currents were stronger and its light brighter than those of its predecessor. In it, moreover, the commutator, the flashing and destruction of which were sources of irregularity and deterioration in the machine of Holmes, was, at the suggestion of M. Masson,[1] entirely abandoned; alternating currents instead of the direct current being employed. M. Serrin modified his excellent lamp with the express view of enabling it to cope with alternating currents. During the International Exhibition of 1862, where the machine was shown, M. Berlioz offered to dispose of the invention to the Elder Brethren of the Trinity House. They referred the matter to Faraday, and he replied as follows: "I am not aware that the Trinity House authorities have advanced so far as to be able to decide whether they will require more magneto-electric machines, or whether, if they should require them, they see reason to suppose the means of their supply in this country, from the source already open to them, would not be sufficient. Therefore I do not see that at present they want to purchase a machine." Faraday was obviously swayed by the desire to protect the interests of Holmes, who had borne the burden and heat which fall upon the pioneer. The Alliance machines were introduced with success at Cape La Hève, near Havre; and the Elder Brethren of the Trinity House, determined to have the best available apparatus, decided, in 1868, on the introduction of machines on the Alliance principle into the lighthouses at Souter Point and the South Foreland. These machines were constructed by Professor Holmes, and they still continue in operation. With regard, then, to the application of electricity to lighthouse purposes, the course of events was this: The Dungeness light was introduced on January 31, 1862; the light at La Hève on December 26, 1863, or nearly two years later. But Faraday's experimental trial at the South Foreland preceded the lighting of Dungeness by more than two years. The electric light was afterward established at Cape Grinez. The light was started at Souter Point on January 11, 1871; and at the South Foreland on January 1, 1872. At the Lizard, which probably enjoys the newest and most powerful development of the electric light, it began to shine on January 1, 1878.

I have now to revert to a point of apparently small moment, but which really constitutes an important step in the development of this subject. I refer to the form given in 1857 to the rotating armature by Dr. Werner Siemens, of Berlin. Instead of employing coils wound transversely round cores of iron, as in the machine of Saxton, Siemens, after giving a bar of iron the proper shape, wound his wire longitudinally

[1] Du Moncel, "L'Électricité," August, 1878, p. 150.

round it, and obtained thereby greatly augmented effects between suitably placed magnetic poles. Such an armature is employed in the small magneto-electric machine which I now introduce to your notice, and for which the institution is indebted to Mr. Henry Wilde, of Manchester. There are here sixteen permanent horseshoe magnets placed parallel to each other, and between their poles a Siemens armature. The two ends of the wire which surrounds the armature are now disconnected. In turning the handle and causing the armature to rotate, I simply overcome ordinary mechanical friction. But the two ends of the armature coil can be united in a moment, and when this is done I immediately experience a greatly increased resistance to rotation. Something over and above the ordinary friction of the machine is now to be overcome, and by the expenditure of an additional amount of muscular force I am able to overcome it. The excess of labor thus thrown upon my arm has its exact equivalent in the electric currents generated, and the heat produced by their subsidence in the coil of the armature. A portion of this heat may be rendered visible by connecting the two ends of the coil with a thin platinum wire. When the handle of the machine is rapidly turned the wire glows, first with a red heat, then with a white heat, and finally with the heat of fusion. The moment the wire melts the circuit round the armature is broken, an instant relief from the labor thrown upon the arm being the consequence. Clearly realize the equivalent of the heat here developed. During the period of turning the machine a certain amount of combustible substance was oxidized or burned in the muscles of my arm. Had it done no external work the matter consumed would have produced a definite amount of heat. Now, the muscular heat actually developed during the rotation of the machine fell short of this definite amount, the missing heat being reproduced to the last fraction in the glowing platinum wire and the other parts of the machine. Here, then, the electric current intervenes between my muscles and the generated heat, exactly as it did a moment ago between the voltaic battery and its generated heat. The electric current is to all intents and purposes a vehicle which transports the heat both of muscle and battery to any distance from the hearth where the fuel is consumed. Not only is the current a messenger, but it is also an intensifier of magical power. The temperature of my arm is, in round numbers, 100° Fahr., and it is by the intensification of this heat that one of the most refractory of metals, which requires a heat of 3,600° Fahr. to fuse it, has been reduced to the molten condition.

Zinc, as I have said, is a fuel far too expensive to permit of the electric light produced by its combustion being used for the common purposes of life, and you will readily perceive that the human muscles, or even the muscles of a horse, would be more expensive still. Here, however, we can employ the force of burning coal to turn our machine, and it is this employment of our cheapest fuel, rendered possible by

Faraday's discovery, which opens out the prospect of our being able to apply the electric light to public use.

In 1866 a great step in the intensification of induced currents, and the consequent augmentation of the magneto-electric light, was taken by Mr. Henry Wilde. It fell to my lot to report upon them to the Royal Society, but before doing so I took the trouble of going to Manchester to witness Mr. Wilde's experiments. He operated in this way: Starting from a small machine like that worked in your presence a moment ago, he employed its current to excite an electro-magnet of a peculiar shape, between whose poles rotated a Siemens armature;[1] from this armature currents were obtained vastly stronger than those generated by the small magneto-electric machine. These currents might have been immediately employed to produce the electric light; but instead of this they were conducted round a second electro-magnet of vast size, between whose poles rotated a Siemens armature of corresponding dimensions. Three armatures therefore were involved in this series of operations: 1. The armature of the small magneto-electric machine; 2. The armature of the first electro-magnet, which was of considerable size; and, 3. The armature of the second electro-magnet, which was of vast dimensions. With the currents drawn from this third armature, Mr. Wilde obtained effects, both as regards heat and light, enormously transcending those previously known.[2]

But the discovery which, above all others, brought the practical question to the front is now to be considered. On the 4th of February, 1867, a paper was received by the Royal Society from Mr. William Siemens, bearing the title, "On the Conversion of Dynamic into Electrical Force without the Use of Permanent Magnetism."[3] On the 14th of February a paper from Sir Charles Wheatstone was received, bearing the title, "On the Augmentation of the Power of a Magnet by the

[1] Page and Moigno had previously shown that the magneto-electric current could produce powerful electro-magnets.

[2] Mr. Wilde's paper is published in the "Philosophical Transactions" for 1867, p. 89. My opinion regarding Wilde's machine was briefly expressed in a report to the Elder Brethren of the Trinity House on the 17th of May, 1866: "It gives me pleasure to state that the machine is exceedingly effective, and that it far transcends in power all other apparatus of the kind."

[3] A paper on the same subject, by Dr. Werner Siemens, was read on the 17th of January, 1867, before the Academy of Sciences in Berlin. In a letter to "Engineering," No. 622, p. 45, Mr. Robert Sabine states that Professor Wheatstone's machines were constructed by Mr. Stroh in the months of July and August, 1866. I do not doubt Mr. Sabine's statement; still it would be dangerous in the highest degree to depart from the canon, in asserting which Faraday was specially strenuous, that the date of a discovery is the date of its publication. Toward the end of December, 1866, Mr. Alfred Varley also lodged a provisional specification (which, I believe, is a sealed document) embodying the principles of the dynamo-electric machine, but some years elapsed before he made anything public. His brother, Mr. Cromwell Varley, when writing on this subject in 1867, does not mention him ("Proceedings of the Royal Society," March 14, 1867). It probably marks a national trait that sealed communications, though allowed in France, have never been recognized by the scientific societies of England.

Reaction thereon of Currents induced by the Magnet itself." Both papers, which dealt with the same discovery, and which were illustrated by experiments, were read upon the same night, viz., the 14th of February. The whole field of science hardly furnishes a more beautiful example of the interaction of natural forces than that set forth in these two papers. You can hardly find a bit of iron—you can hardly pick up an old horseshoe, for example—that does not possess a trace of permanent magnetism; and from such a small beginning Siemens and Wheatstone have taught us to rise by a series of interactions between magnet and armature to a magnetic intensity previously unapproached. Conceive the Siemens armature placed between the poles of a suitable electro-magnet. Suppose this latter to possess at starting the faintest trace of magnetism; when the armature rotates, currents of infinitesimal strength are generated in its coil. Let the ends of that coil be connected with the wire surrounding the electro-magnet. The infinitesimal current generated in the armature will then circulate round the magnet, augmenting its intensity by an infinitesimal amount. The strengthened magnet instantly reacts upon the coil which feeds it, producing a current of greater strength. This current again passes round the magnet, which immediately brings its enhanced power to bear upon the coil. By this play of mutual give and take between magnet and armature, the strength of the former is raised in a very brief interval from almost nothing to complete magnetic saturation. Such a magnet and armature are able to produce currents of extraordinary power, and if an electric lamp be introduced into the common circuit of magnet and armature, we can readily obtain a most powerful light.[1] By this discovery, then, we are enabled to avoid the trouble and expense involved in the employment of permanent magnets; we are also enabled to drop the exciting magneto-electric machine, and the duplication of the electro-magnets. By it, in short, the electric generator is so far simplified, and reduced in cost, as to enable electricity to enter the lists as the rival of our present means of illumination.

Soon after the announcement of their discovery by Siemens and Wheatstone, Mr. Holmes, at the instance of the Elder Brethren of the Trinity House, endeavored to turn this discovery to account for lighthouse purposes. Already, in the spring of 1869, he had constructed a machine which, though hampered with defects, exhibited extraordinary power. The light was developed in the focus of a dioptric apparatus placed on the Trinity Wharf at Blackwall, and witnessed by the Elder Brethren, Mr. Douglass, and myself, from an observatory at Charlton, on the opposite side of the Thames. Falling upon the suspended haze, the light illuminated the atmosphere for miles all round. Anything so sunlike in splendor had not, I imagine, been previously witnessed. The

[1] In 1867 Mr. Ladd introduced the modification of dividing the armature into two separate coils, one of which fed the electro-magnets, while the other yielded the induced currents.

apparatus of Holmes, however, was rapidly distanced by the safer and more powerful machines of Siemens and Gramme.

As regards lighthouse illumination, the next step forward was taken by the Elder Brethren of the Trinity House in 1876-'77. Having previously decided on the establishment of the electric light at the Lizard in Cornwall, they instituted at the time referred to an elaborate series of comparative experiments wherein the machinery of Holmes, of the Alliance Company, of Siemens, and of Gramme, were pitted against each other. The Siemens and the Gramme machines delivered direct currents, while those of Holmes and the Alliance Company delivered alternating currents. The light of the latter was of the same intensity in all azimuths round the place of observation; that of the former was different in different azimuths, the discharge being so regulated as to yield a gush of light of special intensity in one direction. The following table gives in standard candles the performance of the respective machines:[1]

Name of Machines.	Maximum.	Minimum.
Holmes	1,523	1,523
Alliance	1,953	1,953
Gramme (No. 1)	6,663	4,016
" (No. 2)	6,663	4,016
Siemens (large)	14,818	8,932
" (small, No. 1)	5,359	3,339
" (small, No. 2)	6,864	4,138
Two Holmes's coupled	2,811	2,811
Two Gramme's	11,396	6,869
Two Siemens's (Nos. 1 and 2)	14,134	8,520

These determinations were made by Mr. Douglass, the engineer-in-chief, and Mr. Ayres, the assistant engineer of the Trinity House. After this contest, which was conducted throughout in the most amicable manner, Siemens machines of the smaller type were chosen for the Lizard.[2]

We have machines capable of sustaining a single light and also machines capable of sustaining several lights. The Gramme machine, for example, which ignites the Jablochkoff candles on the Thames Embankment and at the Holborn Viaduct, delivers four currents, each passing through its own circuit. In each circuit are five lamps through which the current belonging to the circuit passes in succession. The lights correspond to so many resisting spaces, over which, as already explained, the current has to leap; the force which accomplishes the

[1] Observations from the sea on the night of November 21, 1876, made the Gramme and small Siemens practically equal to the Alliance. But the photometric observations, in which the external resistance was abolished, and previous to which the light-keepers had become more skilled in the management of the direct current, showed the differences recorded in the table. A close inspection of these powerful lights at the South Foreland caused my face to peel, as if it had been irritated by an Alpine sun.

[2] As the result of a recent trial by Mr. Schwendler, they have been also chosen for India.

leap being that which produces the light. Whether the current is to be competent to pass through five lamps in succession, or to sustain only a single lamp, depends entirely upon the will and skill of the maker of the machine. He has, to guide him, definite laws laid down by Ohm half a century ago, by which he must abide.

Ohm has taught us how to arrange the elements of our battery so as to augment indefinitely its electro-motive force—that force, namely, which urges the current forward and enables it to surmount external obstacles. We have only to link the cells together so that the current generated by each cell shall pass through all the others, and add its electro-motive force to that of all the others. We increase, it is true, at the same time the resistance of the battery, diminishing thereby the quantity of the current from each cell, but we augment the power of the integrated current to overcome external hindrances. The resistance of the battery itself may, indeed, be rendered so great that the external resistance shall vanish in comparison. What is here said regarding the voltaic battery is equally true of magneto-electric machines. If we wish our current to leap over five intervals, and produce five lights in succession, we must invoke a sufficient electro-motive force. This is done through multiplying by the use of thin wires the convolutions of the rotating armature as, a moment ago, we augmented the cells of our voltaic battery. Each additional convolution, like each additional cell, adds its electro-motive force to that of all the others; and, though it also adds its resistance, thereby diminishing the quantity of current contributed by each convolution, the integrated current becomes endowed with the power of leaping across the successive spaces necessary for the production of a series of lights in its course. The current is, as it were, rendered at once thinner and more piercing by the simultaneous addition of internal resistance and electro-motive power. The machines, on the other hand, which produce only a single light have a small internal resistance associated with a small electro-motive force. In such machines the wire of the rotating armature is comparatively short and thick, copper ribbon instead of wire being commonly employed. Such machines deliver a large quantity of electricity of low tension—in other words, of low leaping power. Hence, though competent when their power is converged upon a single interval to produce one splendid light, their currents are unable to force a passage when the number of intervals is increased. Thus, by augmenting the convolutions of our machines, we sacrifice quantity and gain electro-motive force; while, by lessening the number of the convolutions, we sacrifice electro-motive force and gain quantity. Whether we ought to choose the one form of machine or the other depends entirely upon the external work the machine has to perform. If the object be to obtain a single light of great splendor, machines of low resistance and large quantity must be employed. If we want to obtain in the same circuit several lights of moderate intensity, machines of high internal

resistance and of correspondingly high electro-motive power must be invoked.

When a coil of covered wire surrounds a bar of iron, the two ends of the coil being connected together, every alteration of the magnetism of the bar is accompanied by the development of an induced current in the coil. The current is only excited during the period of magnetic change. No matter how strong or how weak the magnetism of the bar may be, as long as its condition remains permanent no current is developed. Conceive, then, the pole of a magnet placed near one end of the bar to be moved along it toward the other end. During the time of the pole's motion there will be an incessant change in the magnetism of the bar, and accompanying this change we shall have an induced current in the surrounding coil. If, instead of moving the magnet, we move the bar and its surrounding coil past the magnetic pole, a similar alteration of the magnetism of the bar will occur, and a similar current will be induced in the coil. You have here the fundamental conception which led M. Gramme to the construction of his beautiful machine.[1] He aimed at giving continuous motion to such a bar as we have here described ; and for this purpose he bent it into a continuous ring, which, by a suitable mechanism, he caused to rotate rapidly close to the poles of a horseshoe magnet. The direction of the current varied with the motion and with the character of the influencing pole. The result was that the currents in the two semicircles of the coil surrounding the ring flowed in opposite directionss. But it was easy, by the mechanical arrangement called a commutator, to gather up the currents and cause them to flow in the same direction. The first machines of Gramme, therefore, furnished *direct* currents, similar to those yielded by the voltaic pile. M. Gramme subsequently so modified his machine as to produce alternating currents. Such machines are employed to produce the lights now exhibited on the Holborn Viaduct and the Thames Embankment.

Another machine of great alleged merit is that of M. Lontin. It resembles in shape a toothed iron wheel, the teeth being used as cores, round which are wound coils of copper wire. The wheel is caused to rotate between the opposite poles of powerful electro-magnets. On passing each pole the core or tooth is strongly magnetized, and instantly evokes in the surrounding coil an induced current of corresponding strength. The currents excited in approaching and retreating, and in passing different poles, move in opposite directions, but by means of a commutator these conflicting electric streams are gathered up and caused to flow in a common bed. The bobbins in which the currents are induced can be so increased in number as to augment indefinitely the power of the machine. To excite his electro-magnets, M. Lontin applies the principle of Mr. Wilde. A small machine furnishes a direct

[1] "Comptes Rendus," 1871, p. 176. See also Gaugain on the Gramme machine, "Ann. de Chim. et de Phys.," vol. xxviii., p. 324.

current, which is carried round the electro-magnets of a second and larger machine. Wilde's principle, it may be added, is also applied on the Thames Embankment and the Holborn Viaduct; a small Gramme machine being used in each case to excite the electro-magnets of the large ones.

The Farmer-Wallace machine is also an apparatus of great power. It consists of a combination of bobbins for induced currents, and of inducing electro-magnets, the latter being excited by the method discovered by Siemens and Wheatstone. In the machines intended for the production of the electric light, the electro-motive force is so great as to permit of the introduction of several lights in the same circuit. A peculiarly novel feature of the Farmer-Wallace system is the shape of the carbons. Instead of rods two large plates of carbons with beveled edges are employed, one above the other. The electric discharge passes from edge to edge, and shifts its position according as the carbon is dissipated. The duration of the light in this case far exceeds that obtainable with rods. I have myself seen four of these lights in the same circuit in Mr. Ladd's workshop in the city, and they are now, I believe, employed at the Liverpool Street Station of the Metropolitan Railway. The Farmer-Wallace "quantity machine" pours forth a flood of electricity of low tension. It is unable to cross the interval necessary for the production of the electric light, but it can fuse thick copper wires. When sent through a short bar of iridium, this refractory metal emits a light of extraordinary splendor.[1]

The machine of M. de Méritens, which he has generously brought over from Paris for our instruction, is the newest of all. In its construction he falls back upon the principle of the magneto-electric machine, employing permanent magnets as the exciters of the induced currents. Using the magnets of the Alliance Company, by a skillful disposition of his bobbins, M. de Méritens produces with eight magnets a light equal to that produced by forty magnets in the Alliance machines. While the space occupied is only one fifth, the cost is little more than one fourth that of the latter. In the De Méritens machine the commutator is abolished. The internal heat is hardly sensible, and the absorption of power, in relation to the effects produced, is small. With his larger machines M. de Méritens maintains a considerable number of lights in the same circuit.[2]

In relation to this subject inventors fall into two classes, the contrivers of regulators and the constructors of machines. M. Rapieff has hitherto belonged to inventors of the first class, but I have reason to

[1] The iridium light was shown by Mr. Ladd. It brilliantly illuminated the theatre of the Royal Institution.

[2] The small machine transforms one and a quarter horse-power into heat and light, yielding about 1,900 candles; the large machine transforms five horse-power, yielding about 9,000 candles.

know that he is engaged on a machine which, when complete, will place him in the other class also. Instead of two single carbon rods, M. Rapieff employs two pairs of rods, each pair forming a V. The light is produced at the common junction of the four carbons. The device for regulating the light is of the simplest character. At the bottom of the stand which supports the carbons are two small electro-magnets. One of them, when the current passes, draws the carbons together, and in so doing throws itself out of circuit, leaving the control of the light to the other. The carbons are caused to approach each other by a descending weight, which acts in conjunction with the electro-magnet. Through the liberality of the proprietors of the "Times" every facility has been given to M. Rapieff to develop and simplify his invention at Printing House Square. The illumination of the press-room, which I had the pleasure of witnessing, under the guidance of M. Rapieff himself, is extremely effectual and agreeable to the eye. There are, I believe, five lamps in the same circuit, and the regulators are so devised that the extinction of any lamp does not compromise the action of the others. M. Rapieff has lately improved his regulator.

Many other inventors might here be named, and fresh ones are daily crowding in. Mr. Werdermann has been long known in connection with this subject. Employing as negative carbon a disk, and as positive carbon a rod, he has, I am assured, obtained very satisfactory results. The small resistances brought into play by his minute arcs enable Mr. Werdermann to introduce a number of lamps into a circuit traversed by a current of only moderate electro-motive power. M. Reynier is also the inventor of a very beautiful little lamp, in which the point of a thin carbon rod, properly adjusted, is caused to touch the circumference of a carbon wheel which rotates underneath the point. The light is developed at the place of contact of rod and wheel. One of the last steps, though I am informed not quite the last, in the improvement of regulators is this: The positive carbon wastes more profusely than the negative, and this is alleged to be due to the greater heat of the former. It occurred to Mr. William Siemens to chill the negative artificially, with the view of diminishing or wholly preventing its waste. This he accomplishes by making the negative pole a hollow cone of copper, and by ingeniously discharging a small jet of cold water against the interior of the cone. His negative of copper is thus caused to remain fixed in space, for it is not dissipated, the positive carbon only needing control. I have seen this lamp in action, and can bear witness to its success.

I might go on to other inventions, achieved or projected. Indeed, there is something bewildering in the recent rush of constructive talent into this domain of applied electricity. The question and its prospects are modified from day to day, a steady advance being made toward the improvement both of machines and regulators. With regard to our public lighting, I strongly lean to the opinion that the electric light

will at no distant day triumph over gas. I am not so sure that it will do so in our private houses. As, however, I am anxious to avoid dropping a word here that could influence the share market in the slightest degree, I limit myself to this general statement of opinion.

To one inventor in particular belongs the honor of the idea, and the realization of the idea, of causing the carbon rods to burn away like a candle. It is needless for me to say that I here refer to the young Russian officer, M. Jablochkoff. He sets two carbon rods upright at a small distance apart, and fills the space between them with an insulating substance like plaster of Paris. The carbon rods are fixed in metallic holders. A momentary contact is established between the two carbons by a little cross-piece of the same substance placed horizontally from top to top. This cross-piece is immediately dissipated or removed by the current, the passage of which once established is afterward maintained. The carbons gradually waste, while the substance between them melts like the wax of a candle. The comparison, however, only holds good for the act of melting; for, as regards the current, the insulating plaster is practically inert. Indeed, as proved by M. Rapieff and Mr. Wilde, the plaster may be dispensed with altogether, the current passing from point to point between the naked carbons. M. de Méritens has recently brought out a new candle, in which the plaster is abandoned, while between the two principal carbons is placed a third insulated rod of the same material. With the small De Méritens machine two of these candles can be lighted before you; they produce a very brilliant light.[1] In the Jablochkoff candle it is necessary that the carbons should be consumed at the same rate. Hence the necessity for alternating currents by which this equal consumption is secured. It will be seen that M. Jablochkoff has abolished regulators altogether, introducing the candle principle in their stead. In my judgment, the performance of the Jablochkoff candle on the Thames Embankment and the Holborn Viaduct is highly creditable, notwithstanding a considerable waste of light toward the sky. The Jablochkoff lamps, it may be added, would be more effective in a street, where their light would be scattered abroad by the adjacent houses, than in the positions which they now occupy in London.

It was my custom some years ago, whenever I needed a new and complicated instrument, to sit down beside its proposed constructor, and to talk the matter over with him. The study of the inventor's mind which this habit opened out was always of the highest interest to me. I particularly well remember the impression made upon me on such occasions by the late Mr. Darker, a philosophical instrument maker in Lambeth. This man's life was a struggle, and the reason of it was

[1] Both the machines of M. de Méritens and the Farmer-Wallace machine were worked by an excellent gas-engine, lent for the occasion by the Messrs. Crossley, of Manchester. The Siemens machine was worked by steam.

not far to seek. No matter how commercially lucrative the work upon which he was engaged might be, he would instantly turn aside from it to seize and realize the ideas of a scientific man. He had an inventor's power, and an inventor's delight in its exercise. The late Mr. Becker possessed the same power in a very considerable degree. On the Continent, Froment, Breguet, Sauerwald, and others might be mentioned as eminent instances of ability of this kind. Such minds resemble a liquid on the point of crystallization. Stirred by a hint, crystals of constructive thought immediately shoot through them. That Mr. Edison possesses this intuitive power in no common measure is proved by what he has already accomplished. He has the penetration to seize the relationship of facts and principles, and the art to reduce them to novel and concrete combinations. Hence, though he has thus far accomplished nothing that we can recognize as new in relation to the electric light, an adverse opinion as to his ability to solve the complicated problem on which he is engaged would be unwarranted.

I will endeavor to illustrate in a simple manner Mr. Edison's alleged mode of electric illumination, taking advantage of what Ohm has taught us regarding the laws of the current, and what Joule has taught us regarding the relation of resistance to the development of light and heat. From one end of a voltaic battery runs a wire, dividing at a certain point into two branches which reunite in a single wire connected with the other end of the battery. From the positive end of the battery the current passes first through the single wire to the point of junction, where it divides itself between the branches according to a well-known law. If the branches be equally resistant, the current divides itself equally between them. If one branch be less resistant than the other, more than half the current will choose the freer path. The strict law is that the quantity of current is inversely proportional to the resistance. A clear image of the process is derived from the deportment of water. When a river meets an island it divides, passing right and left of the obstacle, and afterward reuniting. If the two branch beds be equal in depth, width, and inclination, the water will divide itself equally between them. If they be unequal, the larger quantity of water will flow through the more open course. And as, in the case of the water, we may have an indefinite number of islands producing an indefinite subdivision of the trunk stream, so in the case of electricity we may have, instead of two branches, any number of branches, the current dividing itself among them, in accordance with the law which fixes the relation of flow to resistance.

Let us apply this knowledge. Suppose an insulated copper rod, which we may call an "electric main," to be laid down along one of our streets, say along the Strand. Let this rod be connected with one end of a powerful voltaic battery, a good metallic connection being established between the other end of the battery and the gas-pipes under the street. As long as the electric main continues unconnected

with the gas-pipes, the circuit is incomplete and no current will flow; but if any part of the main, however distant from the battery, be connected with the adjacent gas-pipes, the circuit will be completed and the current will flow. Supposing our battery to be at Charing Cross, and our rod of copper to be tapped opposite Somerset House, a branch wire can be carried from the rod into the building, the current passing through which may be subdivided into any number of subordinate branches which reunite afterward and return through the gas-pipes to the battery. The branch currents may be employed to raise to vivid incandescence a refractory metal like iridium or one of its alloys. Instead of being tapped at one point, our main may be tapped at one hundred points. The current will divide in strict accordance with law, its power to produce light being solely limited by its strength. The process of division closely resembles the circulation of the blood; the electric main carrying the outgoing current representing a great artery, the gas-pipes carrying the return current representing a great vein, while the intermediate branches represent the various vessels by which the blood is distributed through the system. This, if I understand aright, is Mr. Edison's proposed mode of illumination. The electric force is at hand. Metals sufficiently refractory to bear being raised to vivid incandescence are also within reach. The principles which regulate the division of the current and the development of its light and heat are perfectly well known. There is no room for a "discovery," in the scientific sense of the term, but there is ample room for the exercise of that mechanical ingenuity which has given us the sewing-machine and so many other useful inventions, and which engages a greater number of minds in the United States than in any other nation in the world. Knowing something of the intricacy of the practical problem, I should certainly prefer seeing it in Mr. Edison's hands than in mine.[1]

It is sometimes stated as a recommendation to the electric light, that it is light without heat; but to disprove this it is only necessary to point to the experiments of Davy, which show that the heat of the voltaic arc transcends that of any other terrestrial source. The emission from the carbon points is capable of accurate analysis. To simplify the subject, we will take the case of a platinum wire at first slightly warmed by the current, and then, through the gradual augmentation of the latter, raised to a white heat. When first warmed, the wire sends forth rays which have no power on the optic nerve. They are what we call invisible rays; and not until the temperature of the wire has reached nearly 1,000° Fahr. does it begin to glow with a faint, red light. The rays which it emits prior to redness are all invisible rays, which can warm the hand but can not excite vision. When the temperature of the wire is raised to whiteness these dark rays not only persist, but they are enormously augmented in intensity. They consti-

[1] More than thirty years ago the radiation from incandescent platinum was admirably investigated by Dr. Draper, of New York.

tute about 95 per cent. of the total radiation from the white-hot platinum wire. They make up nearly 90 per cent. of the emission from a brilliant electric light. You can by no means have the light of the carbons without this invisible emission as an accompaniment. The visible radiation is, as it were, built upon the invisible as its necessary foundation.

It is easy to illustrate the growth in intensity of these invisible rays as the visible ones enter the radiation and augment in power. The transparency of the simple gases and metalloids—of oxygen, hydrogen, nitrogen, chlorine, iodine, bromine, sulphur, phosphorus, and even of carbon—for the invisible heat-rays is extraordinary. Dissolved in a proper vehicle iodine cuts the visible radiation sharply off, but allows the invisible free transmission. By dissolving iodine in sulphur, Professor Dewar has recently added to the number of our effectual ray-filters. The mixture may be made as black as pitch for the visible, while remaining transparent for the invisible rays. By such filters it is possible to detach the invisible rays from the total radiation, and to watch their augmentation as the light increases. Expressing the radiation from a platinum wire when it first feels warm to the touch—when, therefore, all its rays are invisible—by the number one, the invisible radiation from the same wire raised to a white heat may be five hundred or more. It is not, then, by the diminution or transformation of the non-luminous emission that we obtain the luminous; the heat-rays maintain their ground as the necessary antecedents and companions of the light-rays. When detached and concentrated these powerful heat-rays can produce all the effects ascribed to the mirrors of Archimedes at the siege of Syracuse. While incompetent to produce the faintest glimmer of light, or to effect the most delicate air-thermometer, they will inflame paper, burn up wood, and even ignite combustible metals. When they impinge upon a metal refractory enough to bear their shock without fusion, they can raise it to a heat so white and luminous as to yield, when analyzed, all the colors of the spectrum. In this way the dark rays emitted by the incandescent carbons are converted into light rays of all colors. Still, so powerless are these invisible rays to excite vision that the eye has been placed at a focus competent to raise platinum-foil to bright redness without experiencing any visual impression. Light for light, no doubt, the amount of heat imparted by the incandescent carbons to the air is far less than that imparted by gas-flames. It is less because of the smaller size of the carbons, and of the comparative smallness of the quantity of fuel consumed in a given time. It is also less because the air can not penetrate the carbons as it penetrates a flame. The temperature of the flame is lowered by the admixture of a gas which constitutes four fifths of our atmosphere, and which, while it appropriates and diffuses the heat, does not aid in the combustion; and this lowering of the temperature by the inert atmospheric nitrogen renders necessary the combustion of a greater amount of gas to produce the

necessary light. In fact, though the statement may appear paradoxical, it is entirely because of its enormous actual temperature that the electric light seems so cool. It is this temperature that renders the proportion of luminous to non-luminous heat greater in the electric light than in our brightest flames. The electric light, moreover, requires no air to sustain it. It glows in the most perfect air-vacuum. Its light and heat are therefore not purchased at the expense of the vitalizing constituent of the atmosphere. It sheds its light without vitiating the air.

Two orders of minds have been implicated in the development of this subject: first, the investigator and discoverer, whose object is purely scientific, and who cares little for practical ends; secondly, the practical mechanician, whose object is mainly industrial. It would be easy, and probably in many cases true, to say that the one wants to gain knowledge, while the other wants to make money; but I am persuaded that the mechanician not unfrequently merges the hope of profit in the love of his work. Members of each of these classes are sometimes scornful toward those of the other. There is, for example, something superb in the disdain with which Cuvier hands over the discoveries of pure science to those who apply them: "Your grand practical achievements are only the easy application of truths not sought with a practical intent—truths which their discoverers pursued for their own sake, impelled solely by an ardor for knowledge. Those who turned them into practice could not have discovered them, while those who discovered them had neither the time nor the inclination to pursue them to a practical result. Your rising workshops, your peopled colonies, your vessels which furrow the seas; this abundance, this luxury, this tumult"—"this commotion," he would have added, were he now alive, "regarding the electric light"—"all come from discoverers in science, though all remain strange to them. The day that a discovery enters the market they abandon it; it concerns them no more."

In writing thus Cuvier probably did not sufficiently take into account the reaction of the applications of science upon science itself. The improvement of an old instrument or the invention of a new one is often tantamount to an enlargement and refinement of the senses of the scientific investigator. Beyond this, the amelioration of the community is also an object worthy of the best efforts of the human brain. Still, assuredly it is well and wise for a nation to bear in mind that those practical applications which strike the public eye, and excite public admiration, are the outgrowth of long-antecedent labors begun, continued, and ended under the operation of a purely intellectual stimulus. "Few," says Pasteur, "seem to comprehend the real origin of the marvels of industry and the wealth of nations. I need no other proof of this than the frequent employment in lectures, speeches, and official language of the erroneous expression, 'applied science.' A statesman

of the greatest talent stated some time ago that in our day the reign of theoretic science had rightly yielded place to that of applied science. Nothing, I venture to say, could be more dangerous, even to practical life, than the consequences which might flow from these words. They show the imperious necessity of a reform in our higher education. There exists no category of sciences to which the name of applied science could be given. We have science and the applications of science which are united as tree and fruit."

A final reflection is here suggested. We have among us a small cohort of social regenerators—men of high thoughts and aspirations—who would place the operations of the scientific mind under the control of a hierarchy which should dictate to the man of science the course that he ought to pursue. How this hierarchy is to get its wisdom they do not explain. They decry and denounce scientific theories; they scorn all reference to ether, and atoms, and molecules, as subjects lying far apart from the world's needs; and yet such ultra-sensible conceptions are often the spur to the greatest discoveries. The source, in fact, from which the true natural philosopher derives inspiration and unifying power is essentially ideal. Faraday lived in this ideal world. Nearly half a century ago, when he first obtained a spark from a magnet, an Oxford don expressed regret that such a discovery should have been made, as it placed a new and facile implement in the hands of the incendiary. To regret, a Comtist hierarchy would have probably added repression, sending Faraday back to his bookbinder's bench as a more dignified and practical sphere of action than piddling with a magnet. And yet it is Faraday's spark which now shines upon our coasts, and promises to illuminate our streets, halls, quays, squares, warehouses, and, perhaps at no distant day, our homes.

THE AARD-VARK OR EARTH-HOG.[1]

By E. OUSTALET.

IN the class *Mammalia* the order *Edentata* is one which offers a very great diversity. To judge from their name, the Edentates should all be animals without teeth; yet, though some of them, as the ant-eater and pangolin, offer this peculiarity, others, on the contrary, as the sloth, the armadillo, and the orycteropus or earth-hog, have the jaws provided with organs of mastication, except the portion where the incisors should be. Again, the nails which terminate the digits of the Edentata are sometimes sharp and hooked, so that the animal may climb easily and suspend itself from the branches of trees; again, they are spade-shaped, so that the animal may excavate the ground. Finally, while in some

[1] Translated from "La Nature," by J. Fitzgerald, A. M.

the integument is reënforced by bony concretions, in others it is covered with imbricate scales, in others clothed with coarse hairs, and in others still perfectly nude. From all this it results that naturalists are greatly puzzled when they have to name the general characteristics of the order. Nevertheless, it may be said that these mammals bear in their skeleton and in the arrangement of their viscera certain signs of inferiority; that their salivary glands are highly developed, a fact accounted for by their insectivorous diet; and that in their circulatory system they present some peculiar features, certain interlacings of the blood-vessels which regulate the flow of the blood to the limbs, which latter usually move with extreme slowness. Furthermore, it may be added that, in Edentata with teeth, those organs have a peculiar aspect, being for the most part void of enamel, and, to all appearance, consisting of a number of cylinders standing side by side.

In the animal world as at present constituted the Edentata are all of medium or even small size; but in former geological epochs they attained very considerable dimensions, rivaling even the elephant. The megatherium, whose bones have been found in Buenos Ayres, was $4\frac{1}{2}$ metres ($14\frac{3}{4}$ feet) in length, and $2\frac{1}{2}$ metres ($6\frac{1}{4}$ feet) in height; and the megalonyx and the mylodon, found in the same locality, were also of gigantic proportions. And it is curious to observe that America, where the remains of these great creatures are found, is still the continent which possesses the greatest abundance of animals belonging to this order. The Old World, on the other hand, possesses only a few species, and Australia none at all, the part of the Edentata being in that strange country played by the Monotremata, Echidna, and Ornithorhynchi.

Some species of the Edentata are well known to our readers. The armadillo and the pangolin are common in our zoölogical gardens; the ant-eater and the sloth are to be seen there too, though far more rarely. But besides these familiar species, there are others which, till recent times, were all unknown in menageries, and of which but a very imperfect idea could be formed from the stuffed specimens in the public collections. To this class belongs especially the orycteropus, or earth-hog, a curious sort of Edentate from tropical Africa, which several travelers, and among them Von Heuglin, had vainly tried to carry to Europe alive. Two or three months ago, however, the Paris Museum of Natural History was so fortunate as to secure an animal of this genus. It is quartered in the monkey-house, sheltered from the cold, and there, no doubt, it will be able to live for some time to come in captivity.

The traveler Kolbe, about the middle of the eighteenth century, was the first to publish some notices of the orycteropus, already known even at that time to the Dutch settlers under the name of aard-vark (earth-hog); a little later Camper procured the skull of one of these animals, and studied its osteological character; but to Étienne Geoffroy Saint-Hilaire belongs the credit of having clearly pointed out the essential

differences which distinguish the orycteropi from the ant-eaters of the American Continent.

The specimens in our museums and the engravings hitherto published in works of natural history give a very imperfect idea of the orycteropus. In the stuffed specimens—the only models the designer

had at his command—the skin was greatly distended, and the body was disproportionately long. As will be seen from the accompanying figure, drawn from life, the orycteropus is, on the contrary, of heavy build,

with arched back, like a pig, which animal it further resembles in that its skin is sparsely strewed with hairs. But its very long ears, instead of being pendent like those of the pig, rise like horns on both sides of the head ; neither is the tail slender or twisted into a corkscrew curl ; on the contrary, it is of conical shape and very thick at the base. Finally, the rather elongated head, terminating in a regular snout, has at its extremity a buccal opening rather larger than in the ant-eater, but yet far smaller than in swine. The teeth, numbering five or six pairs in the lower jaw and six or seven in the upper, increase in size from the first to the one before the last on each side. Their structure is peculiar, being far less dense than in most Mammalia, and having no coating of enamel. The grinding surface is flattened, and the single root is pierced with a number of holes in its periphery. The slender, protractile tongue is, as in nearly all of the Edentata, covered with a viscous substance designed to secure the small insects on which the animal lives. The short, heavy feet terminate, the anterior in four digits, the posterior in five, all armed with strong, hoof-like claws. In the posterior feet, as in the anterior, the external lateral digits are a little shorter than the others.

The family *Orycteropidæ* comprises only a single genus, in which we can, not without much difficulty, distinguish three species, viz. : the Cape orycteropus or earth-hog, the one first known ; the orycteropus of Senegambia, described by Lesson ; and the orycteropus of Ethiopia, studied by D'Abbadie and D'Arnaud on the banks of the White Nile. These three species are identical in their habits, of nearly the same size, 1·3 metre (about $5\frac{1}{4}$ feet) from the snout to the extremity of the skin, and of the same general form ; they differ only in the proportions of the cranium and of the limbs, and in the color and appearance of the skin. Thus, in the Cape orycteropus, for instance, the surface of the body presents a scanty covering of straight, soft hairs, which are shorter on the back than on the belly. In the orycteropus of Ethiopia, on the other hand, the skin is almost perfectly nude, with merely a few straggling, brownish hairs on the ears, the tail, and the base of the limbs. To this species belongs the individual recently acquired for the Jardin des Plantes, and of which our figure is a faithful portrait. It will be seen that the body is swollen like a full skin-bottle, and furrowed with creases which radiate from the abdominal region between the paws. The latter are of enormous size, and the tail, which is soft and flabby, falls to the ground by its own weight. The general appearance of the animal is at once mean and grotesque. Looked at from behind, it resembles a bag, the long ears projecting on each side being the ends of the string by which the mouth of the bag is tied.

This orycteropus lives in pairs in the plains of Kordofan, where it is called by the Arabs *abudelatif*, i. e., "the father that owns claws." In the daytime it lies hidden and doubled up in a deep hole, which it digs in the loose soil of the plain by means of its broad, sharp claws. Toward

evening it quits this hiding-place and begins to move about, advancing either by leaps, or else with an unsteady gait, walking nearly always on the extremities of its digits. Whatever may have been written heretofore by naturalists, the orycteropus is in fact digitigrade rather than plantigrade. When the animal is walking the head is inclined, the snout nearly touching the ground, the ears laid half-way back, and the tail trailing. From time to time the animal stops to listen: it is guided principally by hearing and smell, and by the same means contrives to escape from its enemies. On finding a path that has been traveled over by ants or termites, it follows it up to the ant-hill; having reached the latter, it attacks the structure with its paws, making the dust fly all around, and digging rapidly till it comes to the center, or at least to one of the principal streets. Then, alternately exserting and retracting its viscous tongue, it devours the ants by the thousands. Having made an end of one nest it attacks another, and so on till its hunger is appeased. When we consider the alarming rate at which ants and termites multiply, and the damage they cause, we must recognize in the orycteropus one of the most efficient of man's auxiliaries in tropical regions.

The orycteropi are extremely timid: at the slightest noise they try to get underground. If they find no suitable hole or crevice, then they quickly dig for themselves a hiding-place. The late J. Verreaux, who had many a time observed orycteropi at the Cape, has told me of how, having once seized by the tail one of them when it had got but half of its body underground, he could not get the animal out except by having the ground dug to a considerable depth. In eastern Africa the negroes, approaching cautiously, kill the orycteropus by a sudden thrust of a lance before it has time to disappear. In Senegal, on the other hand, the animal is caught in iron traps, or hunted with dogs by night. The skin of the animal is thick, and makes good, strong leather. The flesh is by some travelers described as juicy, with a taste like that of pork; according to others it is disgusting, being strongly impregnated with ant-odor. Levaillant could never bring himself to eat of it.

In captivity the orycteropus seems stupid, passing most of the day in sleep, rolled up into a shapeless mass. The individual at the Jardin des Plantes, since winter came in, never quits its nest till about five or six o'clock in the evening. Then it begins to roam about its quarters, returning constantly to the stove, where it warms itself with evident pleasure while it squats on its hind legs and keeps its snout steadily pointed at the fire.

SCIENCE AND SOCIALISM.[1]

By Professor OSCAR SCHMIDT,
OF THE UNIVERSITY OF STRASBURG.

I MUST assume it to be generally known that in last year's Congress of German Naturalists and Physicians, held at Munich, a prominent member incidentally referred to the points of contact between Socialist Democracy and Darwinism, as also to the momentous and redoubtable consequences which might thence ensue. These words of certainly well-meant admonition were received with delight by all those who in any event can not tolerate the doctrine of descent, and who accordingly heartily approved of making Darwinism responsible for the most exciting social phenomenon of the time.

It is, of course, all right enough if certain representatives of Socialist Democracy think they can with the aid of Darwinism add force to their opinions; but they jumble together doctrines which either are irrelevant, or which mutually exclude one another.

This fact, indeed, is recognized by another portion of the Socialist-Democratic party, who hold that the socialistic idea must have supplanted the Darwinian principle as applied to the human race, before the new form of society can be realized and made to stand.

The political economists have now for more than a century been studying the "Struggle for Life" in its bearings on the weal or woe of mankind, yet not until the advent of Darwin did they consider the problem understandingly. Under what forms individuals and classes compete with one another; in what way this struggle is to be ennobled for the benefit of the race—these and other like questions are agitated on all sides, as witness one work among many, namely, A. Lange's thoughtful book, "On the Labor Question" ("Ueber die Arbeiterfrage"). It is not, therefore, with this well-known point of contact with Darwinism that we have to do, but with the special application of ostensibly Darwinian results to the justification and the execution of the Socialist-Democratic programme.

Although it has been raining "Quintessences of Socialism" for the instruction of the public, nevertheless we must briefly explain how far Socialist Democracy, as realized in the future, purports to be the ultimate term of a natural development.

Having passed through the period of absolute Inculture, a period which might be roughly characterized by community life in troops and minor family groups under the leadership of strong male individuals, traces of which are found in the mammoth and reindeer caves, man next entered the less rude condition of the hunter and the nomad where-

[1] Translated from the "Deutsche Rundschau," by J. Fitzgerald, A. M.

in those minor groups, now developed into clans, rose above the primordial state by their complex organization, their division of labor, and their larger enterprise. But now, as we read in the writings of the Socialist Democrats, with distinction of classes and the institution of personal slavery opens the first epoch of human civilization. In this slavery period the whole man is an instrument of labor, and with all his faculties he is the property of the owner who commands his entire service.

In the second civilization period, characterized by handicraft and the possession of land on the small scale, the still widely diffused custom of socage or compulsory service is a reminiscence of the suppressed institution of slavery. The working people are now burgesses enjoying personal freedom, yet hindered in their spontaneous development by the guild. These craftsmen and workers of the soil are the owners and masters of the implements of their calling. Still they do not attain true enjoyment of life, inasmuch as their whole time is engrossed with mechanical toil, in order to procure a livelihood.

The third estate becomes emancipated from the control of the aristocracy of landlordism, the nobility, and the Church. But already the factory system, the system of production by division of labor, was in operation—a system which strips the workman of his little property, and places him under the control of capital.

The factory system is transformed into machine industry. The simpler tools and machinery of early times, worked by hand, have been in the present century developed into a vast complicity of machines producing motion, transferring motion, and doing the work of mechanical tools. These machines tie the workman fast to themselves, reduce his personal service to a minimum of manipulations, and complete the physical and moral wretchedness of the laboring population by increased employment of women and children.

Machinery is an instrument for the accumulation of capital, and of capital as "unpaid labor" at that.

The development of the various forms of production down to the present time when private capital rules everything, and when small capitalists have no chance as against the great, has been vividly portrayed by Marx. He regards the development of the economic social forms as a natural-history process. ("Capital," page 7.) The proposition on which the whole matter hinges, namely, that regarding "unpaid labor," has the appearance of being so simple and so true, that even to many among the laboring class the grand conclusion appears evident, namely, that "the doom of capitalistic private property is about to be sealed. The expropriators will suffer expropriation." (Ibid., page 793.)

Here we see set forth as the natural consequence of development the violent introduction of the Socialist-Democratic state. With the rise of that form of polity the domination of private capital comes to

an end; machinery is no longer private property, but it, with all the other instruments of production, with all that which is understood by the term capital, is transformed into collective or state capital. Private production gives place to collective production. With the abolition, not indeed of all private property, but of all private capital in so far as the same is employed as a means of production, universal participation in the fruits of the collective production, in the means of enjoyment, and in the higher good things of life, is accorded to the whole race..

In this stage of future development the Socialist idea is fully realized. We will not dwell any further on the happy state of things which they say is sure to come about.

If any one would learn more concerning this "picture of fancy," as Socialism is innocently named in one of its chief organs, he may consult Leopold Jacoby's book, "The Idea of Development" ("Die Idee der Entwickelung," 1874, page 6), where he will find it painted in glowing colors. Or he can get a notion of what it is from Engels's most recent utterances (Eug. Dühring's "Science revolutionized"—"Die Umwälzung der Wissenschaft," 1878).

It would be a great mistake to suppose that in the camp of the Socialist Democrats we must find the state of the future represented as a refined copy of a type belonging to the brute creation: on the contrary, Socialistic writers stoutly maintain that the principle of development implies reconstruction. Nevertheless, for the sake of completeness, we will glance at the animal world and consider there the relations between private and collective capital and private and collective production.

Most animals labor for themselves alone. Their implements of labor (private capital) are represented by their members and their weapons of offense; their gains they employ to sustain life. They gather not into barns. Only among the higher classes of animals do we find association of labor and care on the part of the parents for the welfare of their posterity—instincts which can be regarded as confirmed and inherited habits, for all these instinctive actions resolve themselves into labor with gradually accumulated, inherited private capital.

The consociation of higher animals may have the look of work in common, and not instinctive, as for instance when wolves hunt in packs to obtain food, or when animals graze in herds—a habit originating in the need of mutual protection. The colony structures of beavers, the massed nests of the republican bird, are socialistic improvements, in the case of the beaver made under unfavorable outward conditions, and hence *apparently* the result of the animal's voluntary action.

This deceptive appearance is wanting in the structures of the inferior animals, where societies are formed through propagation by budding, the progeny remaining connected with the mother organism. The single individual of a colony of polyps enjoys not only protection against mechanical injuries in the polypidom secreted by all for all, but

further, in case its local position in the polypidom is unfavorable for taking in food, it is fed by the collective alimentary canal, into which flows the surplus of the individual production. A still more complicated social condition, with strict division of labor, is seen in the jelly-fish known as the "Portuguese man-of-war."

I call attention to these familiar facts in order to show that in the animal kingdom communism and socialism are all the more pronounced the lower the organization of the groups among which they appear; and that, on the other hand, wherever among the higher animals conditions occur which savor of the socialistic principle, in the division of the results of the collective production, the egoism of the individual appears all the stronger. I do not at all mean hence to conclude that the case can not be otherwise in human society.

From the selflessness of the polyp to the egoism of the wolf is a development. How this development has been brought about, and how man must come under its action, Darwin teaches; and Leopold Jacoby tells us that the already quoted gospel of the Social Democracy, namely, Marx's work on "Capital," is "a continuation and complement of Darwin's 'Origin of Species' and his 'Descent of Man.'"

This same opinion was expressed one year earlier in "The People's State" ("Der Volksstaat," 1873, No. 31), and it is now our task to examine into its ground.

The only passage in which Marx himself speaks of any complement of Darwinism, though not in connection with his own researches, but *à propos* of the need of a special history of technology, is where he says: "Darwin has drawn attention to the history of natural technology, that is, the formation of plant and animal organs as production-instruments for the life of animals and plants. Should not equal attention be given to the history of the formation of the production-organs of man in society, seeing that these organs are the material basis of every special society organization?" ("Capital," page 385.)

But the scientific method, that of proving by facts the relations between phenomena, is employed by Marx; and in my opinion he is in the right when he protests against the supposition that his dialectic method is at bottom Hegelian. But neither does he collect all the facts—for example, he knows only on the one hand the oppressor and the extortioner, and on the other their victims reduced to misery—nor does he refrain from gratuitous assumptions, as for instance that of the "Unpaid Labor," the most momentous of them all. Again, it happens that, from his not understanding the results of the doctrine of development, the true and actual relations of sociology to Darwinism are hidden from him. For example, he says that "in reality each special historic mode of production has its own special and historically valid laws of population. An abstract law of population holds for plants and animals only in so far as man does not interfere."

Engels, in the work already quoted (page 491), repeats a similar

proposition; but it is not correct, if we use the term "law" in the one sense permitted by exact natural science. The conditions of propagation among plants and animals, the results of their multiplication, vary according to circumstances; and man with his experiments in breeding does not correct Nature, he only copies her. It is plainly out of the question here to speak of laws of population; it were better instead to say that the conditions of population in each period are the effects of special, variable causes peculiar to each stage of development. Cases which are the result of varying circumstances and events are not laws, nor do they justify us in inferring fixed laws.

The attempt has been made, not indeed by Marx himself, but by one of his followers, Leopold Jacoby, to connect logically, in one continuous process, social evolution and its ultimate term, the Socialist-Democratic ideal, with nature's evolution.

He does the impossible with a sophistical argumentation that reminds us of Hegel's dialectic: he is an enthusiast, but it is not for me to pass judgment on his services to Socialist Democracy. Plainly he is an *enfant terrible* for his party. His scientific ideas are of the narrowest kind. Nevertheless, we must reckon with him, since he is the only Socialist-Democrat writer who makes any pretense to observe scientific method in this matter, i. e., the connection between the theory of development and Socialist Democracy. We will later consider Engels's relation to that subject.

Social evolution is nowadays represented by the leaders of Socialist Democracy as being a process of perfectionment necessarily progressing toward a definite end; and as, rightly enough, they do not divorce man from nature, it is plainly their purpose to discover oneness and continuity in social and in natural evolution.

Revolution, say the Social Democrats, is correction of perverted conditions or re-formation for the sake of improvement. Copernicus happily expressed this idea when he gave to his work which upset the astronomical notions of his time the title "De Revolutionibus." It is of no consequence whatever that this is not the true title of the book, but "De Orbium Cœlestium Revolutionibus," or that "revolutio" means a turning round and not an overturning.

In short, in these revolutions, as the Socialist-Democratic philosophy further teaches, "we recognize an ever self-perfecting origination and formation of things in the universe": so much we learn from Kant and Laplace. Then came Lamarck with the "doctrine of the continuous and successive development of organic beings on the earth," but for half a century he failed to obtain a hearing till Darwin procured for the doctrine full acceptance. Thus we have to thank Lamarck and Darwin for the fact that we understand the nature of the two great "revolutions," whereof the one produced the existence of organisms in the transition of the inorganic into the organic, while the idea of the other had for its object the appearance of man.

Thus the philosophy of Social Democracy resembles that of Plato, in teaching that the *idea* hovers over the bodily form. It is the *idea* that dominates everywhere, determining the forms of all things. Hence, down to the advent of man there was in nature a steady, thorough, unconscious striving.

And here comes in another great revolution, the third—viz., the universal apparition of the consciousness of the human race, the philosophical establishment of which is the task which Marx has set himself. Thus, then, as we read in the "Volksstaat" (*ubi supra*), "Darwin and Marx have, by their profound and ingenious researches, carried on in totally different scientific fields, attained results of the utmost importance to mankind, and which, being intimately correlated, mutually support and complement one another."

As Social Democracy holds the accomplishment of its ends to be inevitable and necessary, so, as we have seen, it is one of its cardinal principles that all the phenomena which take place in matter, and all developments of matter, are prefigured and predetermined in the idea. The honest workingman thus learns that a statue is less successful, the less conscious the sculptor was of the idea of the work of beauty inherent in the marble block, and the more he suffered himself during his labor to be influenced by considerations of profit and the like. "In this example of the sculptor and his work, we have," says Jacoby, "a direct proof (direct proof !) of the truth of the proposition that ideas are contained in unconscious nature."

I shall be asked whether the utterances just recounted represent the sympathy between Socialist Democracy and Darwinism—whether these abstract and rather curious and confused theses and propositions represent the dangerous elements, that is, the politically dangerous elements imported into Socialist Democracy from the development theory.

With a few additions, which we will make further on, they do!

How, then, does Darwinism stand with respect to these cardinal ideas of the socialistic development doctrine, as laid down by a philosopher of that school?

We find here two ideas wherein Socialist Democracy purports to be at one with the scientific doctrine of Evolution, viz., Development or Revolution is re-formation—i. e., correction of perverted conditions; and All development has for its basis an idea which designates the future goal, and which governs the movement toward the same. In themselves these propositions are plainly innocent enough, and if they were a result of Darwinian research, they need not be disowned. But Darwinism disclaims the honor of having established any such principles.

What we call *origin*, or *development of species*, is in the first place not a reversal of perverted conditions. In such play upon words we have never indulged. The Darwinian principle of development is Natural Selection, and people are not wont to select from perverted types. It is true that the struggle amid which selection goes on includes also

the struggle against wrong, when it is waged consciously, but generally it is a *struggle against environment.*

We have first to take into consideration the downfall of the one that struggles. But nature, or if you choose the law of nature, recognizes here no distinction of right and wrong: the question is purely one of might. That one is defeated who possesses the least means, the least amount of fight-capital, however sufficient and abundant the same might be under circumstances different from those here and now prevailing. Certainly no scientific man has ever dreamed of subsuming this case under the Hegelian phrases evil—good, negation—position, perversion—correction, etc.

The opposite of this first instance of the outcome of the struggle for existence is seen where one party, by a process of gradual perfectionment, prevails over its opponents and the environment. To the philosopher who is searching for analogies, this appears to be the practical fulfillment of the idea of perfectionment. Still, these two extremes do by no means exhaust every possible termination of the struggle; for there is another possible issue—one which, though it be overlooked by the Socialist-Democrat philosophers, is nevertheless of enormously frequent occurrence: *the organism that makes the struggle adapts itself to the environment.* In doing this, it must oftentimes pass through such straits that it parts with some of its perfections and falls to a lower grade, like many a European baron who has in America found use for himself as a cook's assistant. Or it so remolds itself and its habits in adapting itself to the environment that, while it in no wise becomes more perfect, it nevertheless, as far as possible, insures for the future its present rank.

Thus, to illustrate by an example, it has been observed that, as a rule, birds of brilliant plumage, which on that very account are more conspicuous objects to their enemies, are far more careful to conceal their nests than birds which are not so conspicuous. This we explain on the theory that the ancestors of the bright-colored species by degrees became wise by experience, and that this experience, reënforced by habit, was transmitted to their progeny by heredity. Natural selection keeps pace with experience and habit. In the case of these birds, the change in nesting is a step of progress, but they have not thereby gained any perfection.

If in the historic evolution of organic nature we saw progress only, we should be strongly tempted to regard progress, pure and simple, as a universal natural law for social development as well. But the lesson taught us by birds of brilliant plumage (to say nothing of the loss of acquired perfection) is repeated throughout the whole world of lowly and lowest organisms. These have stood stock-still and must so remain, despite the perfection attained in many directions. The persistence of the low and the imperfect finds its very simple explanation in the persistence of its universally prevailing life-conditions. Millions and mil-

lions of lowly species have perished one after another, giving way to better, i. e., to stronger; and many millions whose slightly variant ancestors escaped from their enemies and rivals have survived. A sea peopled only by fishes, or the land only by mammals, is something unnatural. Thus, the imperfect endures; the perfect, the homogeneous, left to itself alone, becomes self-destructive, as the New-Zealanders began to prey on each other so soon as they had exterminated their only edible wild animal, the dinornis.

In short, Darwinism shows that the evolution of organic life is not to be summed up in a few abstract formulæ. It calls attention to the fact that with the gradual succession of species goes on, *with other movements*, a slow perfectionment in different directions; and this necessary but yet only *partial* progress it seeks to explain by "selection of the fittest" in the decay *or* the backwardness of less gifted individuals and species.

In the whole system of Darwinism we find, unfortunately, no hint of a law which shall in advance determine this perfectionment; and it is laughable to observe how, on the one side, people are complaining that we set up Chance on a throne as a universal principle, while, on the other side, people are making the discovery that the guiding principles of the Socialist Democrats, those principles which are shaping the future, are corollaries of the theory of development.

The strength of the Socialist-Democratic teaching lies in this, that the candidates and members of the party, men unpracticed in logical thinking, are sternly schooled in a few principles, and taught to regard the actualization of *the idea* as something necessary *ex necessitate rei.* The fundamental mistake of supposing that Social Democracy has any point of contact with Darwinism arises, as we have explained, out of the supposition that Darwinism too has brought to light ideas which govern organic transformation—such ideas as are supposed to be necessary for calling forth social revolutions.

The Socialist Democrats do away, after their own fashion, with the personal Godhead, and for this, of course, "atheistic science" is held to answer. In L. Jacoby's work we read:

> We call the idea the foreknown existence of the embodied total result of a progressive re-formation. But this foreknowledge can exist in no other way save this, that the thing to which we grant the idea has itself been carried into the progressive re-formation; and from this knowledge follows the other side of the essence of the idea, namely, the being dominated by the idea, the being forcibly moved by the idea in a given direction. If to these first organisms we allow the idea of Man, we *ipso facto* recognize their domination by this idea; in other words, we see how *they have been constrained so to transform themselves as finally to produce from themselves man.*

This thought, stripped of the studied verbiage in which it is here invested, has very generally become rooted in the minds of the Socialist Democrats. In this way they have set up, in the place of a personal

God, a sort of infallible bugbear under the guise of an Omnipotent Idea. The whole thing is misty, mystic, supernatural, in no sense scientific, least of all is it a Darwinian explication of facts.

Darwinism holds the exact opposite of all this, maintaining that development does *not* proceed according to ideas. Darwinism sees in nature only forces, laws, causes, and effects. Ideas it must for the present leave to the philosophers; and, moreover, it has absolutely no points of contact with the doctrine of ideas contained in the Socialist-Democrat catechism. Hence, when the Socialist Democracy bases the realization of its ideal on the fact that men who are conscious of the impelling ideas must irresistibly push on the work, and so carries the masses on into a belief in these ideas, it must itself be held responsible. *As for Darwinism, it gives no encouragement to such imaginings*, and hence must, in this respect, be simply indifferent for all, whether they hate Social Democracy or whether they love it.

But there is a category of scientific men who look on the origin of species as a development of the higher out of the lower; who find the Darwinian principle insufficient; who will have nothing unaccounted for, and who therefore conceal their ignorance under such phrases as "tendency to perfection" or "aiming at an end." I might also refer to the "Philosophy of the Unconscious"—now, as I believe, in process of decay—a philosophy which, whenever it knows not how to explain anything, solemnly invokes the aid of its "Unconscious." Between these muddled auxiliaries and the Socialist Democrat's "ideas which govern revolutions and determine the re-formation of perverted conditions," there exists an unmistakable though perhaps "unconscious" relationship.

There is, then, a point of contact between Socialist Democracy and Darwinism; but, as far as we have examined it, it is seen to rest on erroneous suppositions and ignorance of the essence of the development doctrine. So far we have found it concerned only with a few theoretical propositions; and we have had nothing to say about the practical realization of the Socialistic idea, or of the doctrines which might perhaps be borrowed from Darwinism to add to it strength.

The Socialist Democrats are unanimous in expressing discontent with the social conditions at present existing. But with respect to the specific organization of society in the future their leaders are very reticent. So much is certain, that the great mass of the workingmen, who now have to sell their entire strength for wages that merely suffice to support life, will in the future perform no so-called "unpaid labor." They will have a share in those higher enjoyments the prerequisite condition of which is a higher mental development. Opportunity for attaining this is afforded every one in the Socialist-Democratic state, by a considerable shortening of the hours of purely mechanical toil, and by opening perfectly free schools of every grade. When the whole population has been in this way refined, there is no longer

question of the "rude physical struggle for existence." For since in the time to come each individual will develop his reason, and reason can not endure perversion or wrong, each will labor for all and all for each. Whether, instead of the present division of labor, there will be an arrangement having the same effect, but based on personal inclination and personal fitness ("Zukunft," 1878, page 704); or whether the system of alternation of work will be introduced, so that, as Engels would have it (*ubi supra*, page 173), the man who in the forenoon wheels a barrow is an architect in the afternoon; what is to be done when no workmen offer themselves for certain kinds of labor, while for other kinds there are too many; whether and how the workman is to be entitled to a certain measure of the means of enjoyment according to the nature of his work, or the exertions he puts forth, or his individual needs: these are all open questions. The amicable settlement of these questions presupposes, as we have already observed, a general physical and moral elevation of the individual, of which the present mean intellectual status is but a faint foretaste.

Thus Socialist Democracy demands a more equitable general division of the good things of life, that every one shall have a share in life's pleasures, and it aims to demonstrate the justice and the naturalness of the claim. We are interested in it, inasmuch as appeal is made to Darwinism for its establishment.

The revolution which goes on quietly in Christendom has appealed to the equality which exists beyond the grave. The Revolution of 1789 was more practical, and championed the natural right of the Third Estate—the right of equality and fraternity here on earth. What it was that gave this direction to the revolution, and how it expounded the return to nature and to the truth of which so much was then said, is sufficiently well known. Now, again, as the Socialist Democracy is not alone in affirming, and truly enough too perhaps, we stand on the threshold of a social overturning. Again there is question of an appeal to be made to the inborn rights of man. Next after the basic idea controlling revolution, of which we have already spoken, the Socialistic programme, like the programme of all revolutions which proceed from a general state of distress, insists on the restoration of that equality which is the strictly natural right of every man, but which has been lost, owing to unnatural and perverted social conditions.

The Socialist Democrats are not content with Brentano's view, that humanity's goal is perfection, nor with Held's, that the ideal end of progress is the highest perfectionment of all. Hence they have enlarged the idea of perfectionment by making it include a reduction of labor and an increase of bodily and intellectual enjoyment. That, in the event of a refusal to recognize the justice of this demand, force would be employed to complete its demonstration, is expressed without ambiguity. But it is easy to see how welcome it would be to the leaders of the movement could biology be ranged on their side, and

could Darwinism, "carried out to its logical conclusions," be inscribed on their banner.

If the Socialist-Democratic doctrines had any organic relationship to the anthropological side of Darwinism, science would find its way into it. It would ill befit Science to complain of this. In fact, the Socialist Democrats believe that such alliance has already been effected between science and their philosophy, and it will do no harm to consider the situation, though as conceived by the Socialist Democrats it implies a fundamental misunderstanding.

In the "Volksstaat" (*ubi supra*) we read:

> The Darwinian theory is an important support for Socialism: it is, so to speak, unconsciously its sanction on the part of natural science. For, after all, what is the principal result or the practical meaning of the Darwinian doctrine? Surely, along with a profound insight into the workings of organic nature, it means *the explicit recognition of the doctrine of equality between all men.* If, etc. . . . then surely we may well preach Socialism, inasmuch as every one knows that each individual is a product evolved by nature, and hence having the same claims on nature.

Then the conclusion is drawn that, inasmuch as the reactionaries will not accept the descent of man, they do all they can to prevent the recognition of Darwinism as a support of Socialist Democracy, and to check its diffusion among the people.

How the Socialist Democrats picture to themselves the equality of all men, and first of all the equal natural condition of all men, we see in Jacoby: "Man is good from the beginning"; "The brain of each individual man is capable of being developed so that it shall of itself do all thinking, just as the hand of each individual man is capable of being developed so that it shall do everything with the aid of machinery." That hitherto we have seen only *capacity* for equal development, while *in fact* there exists great inequality of development, is due to the fact that only those who enjoy unnatural privileges have the time requisite for the development of their consciousness. When men shall once have been properly brought up to equality in the Socialistic state, then equal development, with bias toward the good, will come of itself, for "*knowledge of nature compels us to regard all men as beings capable of development in precisely the same measure.*"

But by the term "all men" is to be understood the male portion of the race, for many Socialist Democrats agree with high authorities in holding that woman, by reason of her abnormal brain-structure, must, in the state of the future, act a subordinate part: judgment, action, are not for her, but only feeling, and the faculty of order.

In all this it were difficult to find a single trait that can be referred to the Darwinian anthropology. The Socialist's "aspiration toward perfection" is associated with his ideal of the equality of mankind. Now, *this illusion Darwinism utterly demolishes.* The very principle of development negatives the principle of equality. So far does Dar-

winism go in denying equality, that even where in idea we should have equality, Darwinism pronounces its realization an impossibility. *Darwinism is the scientific establishment of inequality*, and hence the assertion that the Darwinian doctrine is above all a recognition of the doctrine of the equality of all men needs no refutation from our side: it has no foundation in fact.

Again, nowhere in the literature of Darwinism do we find the axioms that "every man is from the beginning good," or that "all men are equal in their capacity for development."

As to what the Darwinians think, let me quote from my book, "Darwinism and the Doctrine of Descent": "The grade to which this (intellectual) development rises is generally dependent on the preceding generations. The psychical capacities of each individual bear the family type, and are determined by the laws of heredity. *For it is simply untrue that, independently of color and descent, each man, under conditions otherwise alike, may attain a like pitch of mental development*" (page 296).

Had it not been that we are held answerable for these ideas of the Socialist Democrats, we should never have esteemed them worthy of notice.

The Socialist Democrats anticipate, when their state shall have been founded, the universal contentment of all men, who shall labor partly out of personal inclination, partly by state ordinance. For this, good men will surely be needed, for one year after the proclamation of equality, the "Volksstaat" (1874, No. 30) demands that "the strong and the weak, the bright and the dull, force of mind and force of body, in so far as they are human, shall in a partnership such as befits human beings be associated in labor, and associated in the enjoyment of its fruits."

Here we must consider that fraction of the Socialist Democrats who with Engels (*ubi supra*, pages 223 *sqq.*, and especially page 235) imagine that the inequality which man inherits from his brute origin, *an inequality that can not be done away*, will be paralyzed under the new social order. As we have seen, some of the Socialists deduce the inequality of human individuals from the unnaturalness of the old form of social organization; they not only maintain a vague idea of equality, but they also expect to see an equal development of individuals, though strong and weak, bright and dull, still continue.

On the other hand, Engels calls the advanced advocates of equality "ghosts," and the demand of the proletariat for an equality beyond the abolition of class, an "absurdity" (page 84); at the same time he is confident that the struggle for existence will cease on the abolition of class distinctions, and will give place to universal mutual good will. This would require that individuals should disregard all actually existent inequalities, whether mental or bodily. Plainly there is no Darwinism here either, and we leave it to others to contest this conversion of the

doctrine of development, a doctrine grounded on observation, into a fiction of the imagination, for we have to do, not with Socialist Democracy as such, but with its relation to Darwinism.

The result of our investigation is, that Socialist Democracy, wherever it appeals to Darwinism, has failed to understand that hypothesis ; that, if it has understood it, it knows not how to draw from it any advantage for itself ; and that it must deny the unalterable principle of Darwinism, namely, competition.[1]

Such is an account of our relations to Socialist Democracy, a movement whose gravity we look on as a sign of a diseased social state that calls for help and salvation.

It remains to define our position with respect to the views of a few of the friends and counselors of the Socialistic movement who, approaching more nearly to the Darwinian point of view, look for the best results for human progress to result from natural selection *after* present social ills have been cured. I refer in particular to Albert Lange. That so eminent a student of human life should estimate at its true value the struggle for existence which has come down to humanity from the unconscious animal world, was to have been expected. He well knew how little warrant there is for the expectation that the "struggle for the more desirable position" will ever cease. But he based his hope on the idea of liberty and equality, an idea that is slowly developed with the developing reason, and which brings men together, in spite of differences of race, or talents, or station. He hoped that the laws of the conscious intelligence would, as time went on, gain the mastery. He hoped for a deliverance to come in the very remote future from a current of thought and feeling which would arise in the developed human mind, and which would run counter to the natural process of differentiation and division. He hoped for a spiritualization of the physical struggle into a peaceful contest, having for its object the good of the race. It is therefore nothing new if in these days like views are put forth by Socialist Democrats.

In his work "The Labor Question," Lange has intimated that certain social evils are the results of artificial selection, and that these might be corrected by a return to simpler natural conditions. If we were to spin out this thought, as is done, for instance, by Dodel in his "Neuere Schöpfungsgeschichte" (1875, pages 145, 147), we might readily persuade ourselves that under the social conditions now existing the principle of natural selection, indeed any purely natural development, "comes into operation either not at all, or only to a limited extent." Then it seems to be an infraction of the natural order, that they who are born to station, so often, without personal worth or talents, monopolize, in virtue of their inherited wealth, the pleasures and enjoyments of life, leaving for their descendants the same even path.

[1] In the "Zukunft" (1878, *ubi supra*) the competition of the future is narrowed down to "a competitive struggle between natural gifts."

Do these favorites of Fortune, it is asked, who take no part in the struggle for existence, constitute the portion of society which is most highly endowed by nature? Ought we to foster such a class for generations to come? In fact, can it be that its continued and prosperous existence has the highest justification?

Out of this preposterous condition of things, where the salutary principle of natural selection is borne down by artificial selection, our one hope of deliverance, we are told, is in the coming of a time "when all the millions who day by day come into existence shall enjoy equal rights of development, so that each individual favored of Fortune, be his birthplace a hovel or a palace, each one endowed with talent or genius, shall find ready prepared for him all the means requisite for developing his natural powers in proportion to their value, and for afterward employing the same for the common good."

I can not accept as correct this explanation of natural and artificial selection. Each individual has, throughout the whole course of historical development, fortified his existence by all the means at his command, with property, with inherited station, by putting forth all his powers of body or of mind, inherited and personal. Artificial selection has a definite end in view: it aims at transforming for a special purpose that which is offered by nature, and then maintaining the new form for the same end. When the nobility, the great landholder class, maintains its position and becomes rooted, we have not an instance of artificial selection in the Darwinian sense, but it is the *natural course of things*, however unnatural the result may seem to be. If this be not admitted, then the whole education of mankind, and every arrangement in the state or in society made consciously and with the object of adding to man's happiness or developing his powers, must be accounted instruments of artificial selection. And among the most artificial of them all would be a regulation of the state which should insure unlimited freedom of development to each individual's talents.

At our point of view we are ever and again reminded that the idea of the natural struggle for existence does not imply that the victorious one is always physiologically, or, in the case of man, morally, the most deserving. We might, but we can not, imagine an ideal state wherein the most deserving shall always gain the victory, and thus we may represent to ourselves a universal perfectionment as the end of development. Hence we are not in the least pessimists; but, on the other hand, the innumerable evidences of progress which we see in nature, both animate and inanimate, do not suffice to make our idea of the universe purely optimistic. Progress is an asymptote of the ideal of perfectionment, and in recognizing this we give free play to the tendency perfectionward, without attempting on our own part to interfere.

With all the certainty that is attainable by inductive proof, the doctrine of development teaches the brute origin of man. Whether Pfeffel says aright—

Weit besser für das Heil der Welt
Ist frommer Irrthum, der erhält,
Als kalte Wahrheit, die zerstört [1]—

may perhaps be open to question in certain cases. In the present case it is worth while to reflect that oftentimes men who awaken from a long-cherished though pious error betray their kinship to the beasts; while truth, sedulously handed down from generation to generation, and advancing enlightenment, make men more human.

Would that we could diffuse abroad a conception of the full truth of the Darwinian doctrine of development, to the end that every thinking man who has not already been caught by the counter-current might know what it comprises and what consequences it does *not* warrant!

THE FIRST THREE YEARS OF CHILDHOOD.

THE readers of the "Monthly" will remember the account of "An Infant's Progress in Language," by F. Pollock, in our September number. We also published an article on "Lingual Development in Babyhood," by M. Taine, in June, 1876. M. Bernard Perez has just published a book upon an analogous subject—the mental development of children under three years of age. The following *résumé* of his observations is translated from the "Revue Scientifique" for November, 1878.

I. Sensibility: Pleasures and Pains of the Senses.—From the first month the fœtus is sensible to the action of cold. Its nervous system commences to react.

Taste.—The first manifestations of pleasure in infancy are due to taste. A child two months and a half old will refuse with grimaces a sucking-bottle filled with water, or with milk too little sweetened.

Touch.—The feather of a quill passed over the eyes and nose of a child fifteen days old will make it frown. Agreeable sensations are not manifested before the age of two months, although they may exist before that time.

Temperature.—Infants die easily of cold even in summer. It is thought, however, that adults suffer more from cold, because they are better able to compare their different states.

Vision.—Color attracts a babe; lively colors charm it, dull colors also please if they are positive and distinct. Two children, one three months, the other five, were delighted by some sketches of a grayish color.

Hearing.—One child a month old liked to listen to playing and

[1] Far better for the welfare of the world is pious error, which sustains, than cold truth, which destroys.

singing. When four or six months old almost all children like to be sung to, and many try to prattle. They please themselves by making a noise.

Smell.—Children for a long time show no sensibility to good and bad odors. At ten or fifteen months their sense of smell is very lively.

II. Sensibility : Emotions and Passions.

Taste.—The emotions connected with taste are for a long time the most lively.

Fear.—Fear is early manifested. A babe of two months will make a face, cry, and recoil upon the bosom of its nurse, if one sneezes or cries out near it.

Jealousy and Anger.—A little girl, nearly three months old, would frown, make wry faces, kick, and cry, on seeing another babe on her mother's breast. A little boy, on the second day, when dressed, gesticulated in a manner painful to see, and especially when his arms were put in the sleeves.

Emotions vary with the Objects.—A little child eleven months old was pleased to hold the nursing-bottle, and to eat various foods; he loved to play ; he showed affection for his parents, and made some difference in this respect between different persons that he liked. He showed aversion for some inanimate objects (hammer syringe) ; for a little black barking dog; and for the caresses of a neighboring child seven years old, who had played him more than one trick. The organization of children being more feeble than ours, their emotions are short-lived, and things the most disagreeable or painful do not long remain so.

Animal Sympathy.—Children love animals, but in a purely egotistic fashion. A child six months old, left alone with a turtle, half tore off one of its feet, and when his nurse came was pulling at another with all his might.

Human Sympathy.—One child a year old, coming home after a month's absence, paid no attention to a cat and dog that he knew well, but with a smile reached out his arms to an old servant. Children have only a germ of true sympathy. A little child four years old lost one of his dearest companions. The father of the dead boy took him on his knee while sobbing. The child escaped, frisked about for a little, and, coming back to the afflicted father, said, "Now Peter is dead, you will give me his horse and drum, will you not ?" Sometimes more sensibility is manifested : a baby of sixteen months would cry to the shedding of hot tears on seeing his father take a shower-bath. The same child at the same time was the terror of cats.

III. Movements (First Period).—The new-born child sneezes.

Cries and Tears.—During its first weeks the babe sheds no tears. In a child seventy-seven days old rapid and short inspirations approached to sobbing ; in another child of one hundred and thirty-eight days M. Perez observed a distinct sob.

Laughing.—Smiling often occurs before the age of a month. Children of two months laugh, but without seeming to suspect that the laugh expresses anything.

Sense.—A little girl three months old would prattle when her mother sang; she had for some time expressed, by particular sounds, her wish to suck.

Various Movements.—A child six days old left, with his arms free, in his cradle, would mechanically carry his hand toward his face, and succeed in placing it almost under his head. We may remark that his father often slept in an analogous position. Children raise and lower their arms and legs with no apparent reason. Some new-born babes move their eyes from the second day. The son of Tiedemann, a philosopher of the eighteenth century, would, when inspiring, suck anything put in his mouth the next day after his birth.

IV. Movements (Second Period).—Between four and eight months the child passes over the interval which separates motion and locomotion. Toward the age of fifteen months he executes many movements—shaking his head from right to left to say no, and bowing it to say yes. The ear and eye have accommodated themselves to distances. The eye expresses many shades of thought, feeling, and will. Laughs, tears, and various movements of the hand serve equally to express emotion.

V. Voluntary Movements.—The new-born child executes some movements that have a definite end. These movements are probably automatic; consciousness is, however, beginning to awaken. When two or three months old the child can put forth a good deal of strength. At four or five months he will make such a stir that it will take several persons to quiet him. Voluntary action is always determined by feeling more or less conscious.

VI. Intellectual Faculties: Consciousness, Attention.—M. Perez thinks that many reflex actions of the child are accompanied by consciousness. The eyes of a little girl a week old would sometimes take a rotary movement, as if trying to see something. When some one spoke, or when certain objects made a great noise, something like surprise and attention, and an intentional direction to her gaze, was noticed. This little girl would suck, but without persistence, all objects, besides the nipple, that were carried to her lips. She cried and wrung herself when put in her cradle, but if her mother took her in her arms, and while singing put her face against the child's, she would cease to cry.

Attention.—A child of seventeen days would follow with its eyes a lighted candle that was passed before him. Another, at the age of a month, would give sustained attention to the act of sucking; its fixed eyes would shine with pleasure, and would from time to time half veil themselves under his eyelids. His sucking-bottle was filled with sweetened water. After a slight hesitation, he continued his sucking with the same expression of voluptuous attention as if the bottle had

contained milk. When given pure water, he tasted it, left it, took hold again, and then abandoned it, frowning and making a mouth. A child a month old would look fixedly, for three or four minutes, at the reflection in a mirror of the light on a table. In forty-five days he would follow with his eyes a doll dressed in bright blue, that a little girl danced before him a yard off. Thirteen days after his birth the son of Tiedemann gave attention to the gestures of those who spoke to him. The attention of children is very short-lived, but it is often profitable.

VII. Memory.—Hereditary memory is manifested in the first reflex actions of the infant. These awaken the consciousness, and the child's own memory often unites itself with them. In a few months a child has already many personal recollections. A little girl three months and a half old could indicate where her feet were ; she also distinguished her dress, which she seemed to take for a part of her person. She had a passion for color ; the word picture made her smile. A little boy seven months old had a particular tenderness for his grandmother, who had fed him with a bottle. A brush was put before him. He put his hands upon it, and soon lifted them with a grave air. The experiment was repeated several times ; at the eighth he threw himself backward, without touching the brush; at the ninth he reflected, hesitated, again drew back, and embraced his grandmother. Memory is also manifested by a sort of intermittent possession of recollections. A little girl eight months old moves her arms as if she were shaking a bell. She is possessed by the idea of this bell, and often amuses herself with it. When she is distracted for a time, she will recommence her movements, and repeat this manœuvre more than twenty times in half an hour. A little child of fifteen months would incessantly repeat the word *a-teau* (bateau), meaning the boat, which he liked very much ; later, two hens along with the boat engrossed his attention. Some months afterward he made a journey, and for the two words he had so often repeated he substituted those of *min-fer* (*chemin de fer*, railroad).

VIII. Association of Sensations, Ideas, and Acts.—When the young Tiedemann, two days old, was placed on his side, in the position for sucking, or when he felt a soft hand on his face, he was hushed, and sought the breast. At five months he had remarked that when his nurse took her mantle it was a signal for going out. So he always rejoiced when that happened. A little child four months and a half old, hearing her nurse call her from behind a door through the keyhole, raised her head, looked right and left, and, at a fresh call, put out her arms, gave starts of joy, of desire, of spite, and finally began to make grimaces. The nurse of a little girl three months and a half old, when going out with the child, bought a bouquet of violets, which she concealed in her bosom. An uncle of the child one day took her in his lap ; he had a pretty rose in his button-hole; the child put out her arms, pressed the vest of her uncle with both hands, applied her lips to his shirt front, and made sucking movements. A child of six months

demanded his bottle, with loud cries, the first thing in the morning, even if it had been given him but the moment before. Thus children associate their sensations; and almost all kinds of associations, fortuitous or logical, may be observed among them.

IX. ABSTRACTION.—We may study in little children the analysis which ends in the idea of the individual, and that which ends in the ideas of form and quantity. At the age of one month several children would follow with their eyes an object in motion near their faces. Children learn only little by little to distinguish different colors. External impressions take hold of them by degrees. "Distinctly to perceive sensations, and to preserve the distinct recollection of them, apart from the vague complexity of concomitant impressions, which have only slightly affected the senses, is a work of repair that may be considered as a sort of rudimentary abstraction." Notions of form ought to arise in consequence of the necessity there is that the child should see things separately in order to see them well, and from especially lively impressions made by certain objects. According to Perez, abstraction is not a result of language. Purely abstract ideas do not exist, and relatively abstract ideas have their origin independently of language.

X. COMPARISON.—Comparison, properly speaking, is not possible to the new-born child for several weeks. A little girl of three months, before whom were put an empty sucking-bottle and one full of milk, seized both, and carried the empty one to her lips. A cake and a morsel of bread were placed before a child of ten months. He seized the cake. It was taken away from him, and he began to cry and kick. Presently a morsel of bread was given him, which he took, but did not see his mistake till he had bitten it, when he threw it away. The same child could easily distinguish its own playthings from those of its comrades, and, while glad to get hold of theirs, would not permit them to amuse themselves with his. After fifteen months, and especially between twenty months and two years, children compare a great deal. When about two years and a half they use such phrases as baby tree (little tree), papa tree (great tree). One child three years old knows the names of more than twenty trees, and can give their more apparent specific characters.

XI. IMAGINATION.—Representative imagination is exercised at the beginning of life. Several facts already given prove this. The vague and profound terror manifested by children is a product of imagination, and so are dreams. The passage from reproductive imagination to creative imagination is effected by a change in the order in which the ideas are represented, a change which frequently occurs during sleep. Creative imagination is shown in a waking state by many acts. The child appreciates fun, and sometimes tries to amuse those who surround it. At four months lacking three days, young Tiedemann tried, for amusement, to make all sorts of movements, and to take different postures. The same faculty manifests itself under the form of destructive

and constructive mania. The imitation of gestures, of expressions, of the cries of animals, indicate the first awakening of the æsthetic sentiment, to which, perhaps, we should also attribute the attraction that certain pictures have for the child. A little boy three and a half years old, being admitted for some weeks to play with a dozen little girls four or five years old, chose his favorites the second day. He had a strong affection for two or three children more playful than the others; he would take them in his arms and caress them, while turning away from the others, scolding them and striking them. The same child early showed a sort of æsthetic musical sentiment. When listening to the piano, he would execute rhythmic jerks or starts. At twenty months children are passionate for the recital of impressions suited to them. Even at three years they take in earnest the stories told them, and often, when these stories are repeated, they will not permit any changes of statement.

XII. Generalization.—M. Perez does not believe that language is necessary to the making of a generalization. He points out to the observer a rudiment of generalization in children that can not talk. A child eight months old had, among his favorite playthings, a tin box, into which he put everything that would go into it. Having found out the property of the box to contain other things, he reasoned from this to unknown objects, and began to experiment. He tried to put the legs of a little dancing jack into the stopper of a decanter, then a little doll's cradle, and finally the end of his forefinger. A child of eight months, at the sight of any young or playful person, would make starts toward her. Besides, even at the time when children express some general ideas by words, they have others which they do not so express. A child of thirteen months, who was refused the hand when he wished to be led, left the person who held him, got down upon the floor, and began to creep. Creeping was for him a means of going along—a means of which he had a very distinct idea.

XIII. Judgment.—If to judge is to believe something of something else, we can not doubt that judgment is manifested by children. The young Tiedemann made a judgment when, seeing his nurse take her mantle, he understood that she was going out. The notion of quantity is early formed by little children, who know very well a large piece of cake from a small one. The idea of number is confounded with that of quantity; a little child of three months seized at the same time two sucking-bottles that were offered him. A child two years and a half old knows how to count twelve, but has not a clear idea of the time represented by three days. In a general way the child often judges very well of concrete matters. Abstract judgments are more difficult for it.

XIV. Reasoning.—The little child reasons, if reason is only a series of consecutive judgments arranged according to the law of habitual association. A child seven months old associates the idea of the

movements of mastication, and the resulting sensations. When he sees his nurse eat, he thinks that what she eats is good for her, and that what is good for her will be good for him. And, as he knows by experience that the nurse can divide with him if she pleases, he begins to cry, in order to make her do it. It is very difficult to distinguish that which is conscious from that which is unconscious in the total manifestations of apparently rationally ordered feelings, ideas, and organic impulses. A child whose father often went fishing was accustomed to eat fried fish. One day his father, coming home after the hour of supper, ate alone. "Me want fry, papa ; me want fry," said he, seeking to get the attention of his father ; he finished by getting under the table, and pulling his father's leg. "Me want fry, not kitty ; me fry ; me want fry." His idea was to imitate the cat in getting under the table, so as to get some fish. Conscious acts are mingled with reflex acts. Children often show a great aptitude in appropriating the experiences arising in new circumstances. A little child, in the neighborhood of two years old, would sometimes, at the table, steal something from his neighbor's plate. He would at once compare the stolen morsel with his own piece, then he would hurry and compress it, so that his larceny would be less apparent.

XV. Of the Expression of Language.—Language is only a superior application of the faculty of expression possessed by all animals. It is based on the correspondence between certain external movements with experienced sensations. Children from the first month cry, prattle, sob, but without attaching any signification to these acts. Association and a sort of selection render these movements and these feelings conscious and voluntary. Hereditary influence ought to interpose in the early progress of language ; for little children quickly learn to distinguish tones of pleasure from tones of anger, etc. At three months the child makes intentional gestures in asking for or refusing a thing. "A child of seven months, who had never seen me," says M. Perez, "smiled as to an old acquaintance on hearing me pronounce his name." At nine months he would give little cries of pleasure and of appeal, some of which were evident attempts to imitate a dog, a cat, a bird. At eleven months he understood some little phrases. A child twelve months old, precocious in language, used a certain number of words in their ordinary sense. A little girl of nineteen months pronounced intelligibly many words, and passed easily from inarticulate to articulate sounds that she sought by instinct, but was aided by imitation. She ended by reproducing the last tonic syllable, of which she could modify the articulation in conformity to the law of least effort. For a long time she said only *bou* for *tambour* (drum), *fé* for *café* (coffee), *yé* for Pierre (Peter). Since then she says *a-bou* for *tambour*, *a-teau* for *gâteau* (cake). The learning of language seems in general to obey the law of least effort ; it is influenced by temperament and by surroundings. The words most easily learned by children are those

which express the most salient qualities of objects, or the part which produces the principal and dominant impression. A little girl twenty months old called the decanter *vé* (*verre*, glass). A little child two years old called all dogs *wa-wa*, except his grandfather's dog, which he did not call by his own name, but only distinguished it from others. Some one made for him a little rounded figure of paper; he said *tété*, the name by which he designated the bosom of his nurse. Intelligent children often forget words that have no meaning for them; children of less intelligence, on the contrary, sometimes replace ideas by words. The mania for jabbering syllables without signification is common with children, even the most intelligent. No doubt they rest from the effort of mind that their first essays in talking cost them in making this noise, which, without requiring any exertion, charms and stuns their ears.

XVI. Notion of Self: Personality, Reflection.—The notion of self may be considered, to a certain extent, as hereditary, and already existing among the impressions of fœtal life. It is developed little by little. The personality of little children is concentrated in the sphere of emotion. They do not know distinctly either themselves or anything else, but they are sensible of the presence of objects, and they are sensible of themselves living, feeling, and acting. At three months the notion of personality is already outlived. When children begin to speak of themselves they employ the third person. M. Perez does not conclude from this that children are unable to separate their personality from external objects. The words *I*, *me*, Paul, Charles, etc., alike express the notion of personal individuality; they designate the personality of the child, a personality that he well knows. When between two and three years old the sentiment of personality is affirmed and exaggerated. A child was very delicate before the age of twenty-six months. His self-love had to be corrected. When eight years old he fell, and before getting up he walked on all-fours, making believe that he had not fallen. At another time he stumbled on the staircase, and rolled over two or three times, purposely bumping his head with a noise. He pretended to have fallen for fun. He was usually pedantic, egotistic, and conceited, but from time to time would show sympathy and diffidence.

XVII. The Moral Sense.—The child has not the absolute idea of good and bad; but he has the objective idea from the age of six or seven months. For him that which is permitted is good, that which is forbidden is bad. A child seven months old had learned from its mother, who had scolded and shaken it, that it ought not to cry to be taken up or held in arms if its wishes were not immediately granted. When ten months old the child began to get up itself in a hesitating way—a moral being. A little child of eleven months obeyed his father very well, particularly when asked to do anything for the amusement or pleasure of others. For little children, the moral law is incarnated in

their parents. A little boy, staying for two or three months with his uncle, would show how his mother managed in reference to him, and cry and gesticulate if things were not done as she did them. He would himself follow the rule of conduct that he tried to impose upon others. "It is very bad to lie," said he; "that gives mamma much pain—that makes her cry." As for the rest, the moral sense is slowly modified, according to the circumstances in which the child is placed. Both sympathy and the desire to please play an important part in the development of the moral faculties. A little girl of forty months was greatly afflicted when her mother said to her, "I am angry with baby." She was, for the most part, indifferent to her father's scoldings, whom she was accustomed to hear cry out at her, and threaten her. The young Tiedemann, when he was two years and five months old, said, when he thought he had done something good, "Everybody will say that is a good little boy." When he was naughty, if he were told, "The neighbors will see you," he ceased immediately. The moral sense is one of the faculties most susceptible of modification by education.

The love of justice sometimes manifests itself. A little boy, the first time he told a lie, was shut in the closet, and when he was set free he cried out, struck with the importance attached to his fault, "But, mamma, perhaps I am not punished enough for a fault so grave." Some children are open-handed to liberality; others, on the contrary, have the instinct of ownership strongly developed, the instinct of appropriation is also manifested, and sometimes becomes the instinct of stealing. Finally, almost all children are cruel; it is hard to prevent them from hurting animals. A little girl, two years old, very affectionate and caressing, passed three fourths of the day tormenting an old dog. The best children are betrayed into striking even those they fondly love.

Conclusion.—We find the germs of all the faculties in the little child, and sensations are the food upon which they grow. We may even say that the essential faculties are innate, since the nervous centers that manifest them are already organized at the moment of birth. The method followed by M. Perez is the scientific method; observation abounds in his work; perhaps, however, some inductions repose upon disputable interpretations. But, be this as it may, the book of M. Perez is full of interest, and can not fail to be of great utility in a study so important, so curious, and so long neglected as the psychology of infants.

THE CHEMICAL ELEMENTS.

By J. NORMAN LOCKYER, F. R. S.

I HAVE recently announced to the Royal Society that, reasoning from the phenomena presented to us in the spectroscope when known compounds are decomposed, I have obtained evidence that the so-called elementary bodies are in reality compound ones.

Although the announcement took this form, the interest taken in science nowadays by the general public is so great that it is apt to travel beyond the record; and, as able editors are not content to wait for what the experimentalist himself has to say, they are often at the mercy of those who, perhaps more from misapprehension than anything else, are prepared to provide columns filled with statements wide of the mark. Nor is this all. If there be a practical side to the work, some "application of science" is brought to the front, and the worker's own view of his labor is twisted out of all truth.

This has happened in my case. The idea of simplifying the elements is connected with the philosopher's stone. The use of the philosopher's stone was to transmute metals; therefore I have been supposed to be "transmuting" metals; and imaginations have been so active in this direction that I am not sure that, when my paper was eventually read at the Royal Society, many were not disappointed that I did not incontinently then and there "transmute" a ton of lead into a ton of gold.

It is in consequence of this general misapprehension of the nature of my work, that I the more willingly meet the wishes of the editor that I should say something about it. The paper itself I need not reproduce, as it has appeared *in extenso* elsewhere [1]; but there are many points touching both the origin of the views I have advanced and the work which has led up to them, on which I am glad of the opportunity of addressing a wider public.

It is now upward of ten years since I began a series of observations having for their object the determination of the chemical constitution of the atmosphere of the sun. The work done, so far as the number of elementary substances found to exist in it, I summed up in a former article [2]; but the ten years' work had opened up a great number of problems above and beyond the question of the number of elements which exist in the solar atmosphere, because we were dealing with elements under conditions which it is impossible to represent and experiment on here.

In the first place, the temperature of the sun is beyond all definition; secondly, the vapors are not confined; and, thirdly, there is an enor-

[1] "American Journal of Science and Arts."

[2] Printed in the "Popular Science Monthly Supplement" for August, 1878.

mous number of them all mixed together, and free, as it were, to find their own level. Nor is this all. Astronomers have not only determined that the sun is a star, and have approximately fixed his place in nature as regards size and brilliancy, but they have compared the spectrum of this star, this sun of ours, with those of the other bodies which people space, and have thus begun to lay the foundations of a science which we may christen Comparative Stellar Chemistry. Dealing with the knowledge already acquired along this line, we may say roughly that there are four kinds of stars recognizable by their spectra.

We have first the brightest and presumably hottest stars, and of these the spectrum is marvelously simple—so simple, in fact, that we say their atmospheres consist in the main of only two substances—a statement founded on the observation that the lines in the spectra are matched by lines which we see in the spectra of hydrogen and calcium; there are traces of magnesium, and perhaps of sodium too, but the faintness of the indication of these two latter substances only intensifies the unmistakable development of the phenomena by which the existence of the former is indicated.

So much, then, for the first class; now for the second. In this we find our sun. In the spectra of stars of this class, the indications of hydrogen are distinctly enfeebled, the evidences by which the existence of calcium has been traced in stars of the first class are increased in intensity, and, accompanying these changes, we find all simplicity vanished from the spectrum. The sodium and magnesium indications have increased, and a spectrum in which the lines obviously visible may be counted on the fingers is replaced by one of terrific complexity.

The complexity which we meet with in passing from the first class to the second is one brought about by the addition of the lines produced by bodies of chemical substances of moderate atomic weight. The additional complexity observed when we pass from the second stage to the third is brought about by the addition of lines due in the main to bodies of higher atomic weight. And—this is a point of the highest importance—at the third stage the hydrogen, which existed in such abundance in stars of the first class, has now entirely disappeared.

In the last class of stars to which I have referred, the fourth, the lines have given place to fluted bands, at the same time that the light and color of the star indicate that we have almost reached the stage of extinction. These facts have long been familiar to students of solar and stellar physics. Indeed, in a letter written to M. Dumas, December 3, 1873, and printed in the "Comptes Rendus," I thus summarized a memoir which has since appeared in the "Philosophical Transactions":

Il semble que plus une étoile est chaude, plus son spectre est simple, et que les éléments métalliques se font voir dans l'ordre de leurs poids atomiques.[1]

Ainsi nous avons:

[1] The old system of atomic weights was the one referred to.

1. Des étoiles très-brillantes où nous ne voyons que l'hydrogène *en quantité énorme*, et le magnésium ;

2. Des étoiles plus froides, comme notre soleil, où nous trouvons:

> Hydrogène + Magnésium + Sodium
> Hydrogène + Magnésium + Sodium + Calcium + Fer, . . . ;

dans ces étoiles, pas de métalloïdes;

3. Des étoiles plus froides encore, dans lesquelles *tous les éléments métalliques sont* ASSOCIÉS, où leurs lignes ne sont plus visibles, et où nous n'avons que les spectres des métalloïdes et des composés.

4. Plus une étoile est âgée, *plus l'hydrogène libre disparaît;* sur la terre, nous ne trouvons plus d'hydrogène en liberté.

Il me semble que ces faits sont les preuves de plusieurs idées émises par vous. J'ai pensé que nous pouvions imaginer une "*dissociation céleste*," qui continue le travail de nos fourneaux, et que le métalloïdes sont des composés qui sont dissociés par la température solaire, pendant que les éléments métalliques monatomiques, dont les poids atomiques sont les moindres, sont précisément ceux qui résistent même à la température des étoiles les plus chaudes.

Before I proceed further I should state that, while observations of the sun have since shown that calcium should be introduced between hydrogen and magnesium for that luminary, Dr. Huggins's photographs have demonstrated the same fact for the stars, so that in the present state of our knowledge, independent of all hypotheses, the facts may be represented as follows:

Hottest Stars .	Lines[1] of	H + Ca + Mg
Sun .		H + Ca + Mg + Na + Fe
Cooler Stars .		— — Mg + Na + Fe + Bi + Hg
Coolest .	Fluted bands of — — — — — —	Fluted Spectra of Metals and Metalloids.

I have no hesitation in stating my opinion that in this line of facts we have the most important outcome of solar work during the last ten years; and if there were none others in support of them, the conclusion would still stare us in the face that *the running down of temperature in a mass of matter which is eventually to form a star is accompanied by a gradually increasing complexity of chemical forms.*

This, then, is the result of one branch of the inquiry, which has consisted in a careful chronicling of the spectroscopic phenomena presented to our study by the various stars.

Experimentalists have observed the spectrum of hydrogen, of calcium, etc., in their laboratories, and have compared the bright lines visible in the spectra with the dark ones in the stars, and on this ground they have announced the discovery of calcium in the sun or of hydrogen in Sirius.

[1] Symbols are used here to save space. H = Hydrogen, Ca = Calcium, Mg = Magnesium, Na = Sodium, Fe = Iron, Bi = Bismuth, Hg = Mercury.

In all this work they have taken for granted that in the spectrum thus produced in their laboratories, they have been dealing with the vibration of one unique thing, call it atom, molecule, or what you will; that one unique thing has by its vibrations produced all the lines visible, which they have persistently seen and mapped in each instance.

It is at this point that my recent work comes in, and raises the question whether what has been thus taken for granted is really true. And now that the question is raised, the striking thing about it is that it was not asked long ago.

One reason is this: Time out of mind—or, rather, ever since Nicolas Le Fèvre, who was sent over here by the French King at the request of our English one at the time the Royal Society was established, pointed out that chemistry was the art of *separations* as well as of *transmutations*—it has been recognized that, with every increase of temperature, or dissociating power, bodies were separated from each other. In this way Priestley, from his "plomb rouge," separated oxygen, and Davy separated potassium; and as a final result of the labor of generations of chemists, the millionfold chemical complexity of natural bodies in the three kingdoms of nature has been reduced by separations till only some seventy so-called elements are left.

Now this magnificent simplification has been brought about by the employment of moderate temperatures—moderate, that is to say, in comparison with the transcendental dissociating energies of electricity as employed in our modern voltaic arcs and electric sparks.

But, in the observations made during the last thirty years on the spectra of bodies rendered incandescent by electricity, *we have actually, though yet scarcely consciously, been employing these transcendental temperatures*, and, if it be that this higher grade of heat does what all other lower grades have done, then the spectrum we have observed in each case is not the record of the vibrations of the particular substance with which we have imagined ourselves to be working only, but of all the simpler substances produced by the series, whether short or long, of the "separations" effected.

The question, then, it will be seen, is an appeal to the law of continuity, nothing more and nothing less. Is a temperature higher than any yet applied to act in the same way as each higher temperature, which has been applied, has done? Or is there to be some unexplained break in the uniformity of nature's processes?

The definite reason for my asking the question at the present time has been this: The final reduction of four years' work at a special branch of the subject to which I will refer presently, on the assumption that at the temperature of the electric arc we do not get such "simplifications," has landed me in the most helpless confusion, and, if I do not succeed in finding a higher law than that on which I have been working, my four years' work, in this direction at all events, will have been thrown away.

This and other reasons compel me to hold that the answer to the question put is, that what has been taken for granted is, in all probability, *not* true. But before I proceed to give the reasons for the faith that is in me I must, at the risk of being both technical and tedious when I should wish to be neither, lead up to the understanding of them.

The spectroscope, however simple or complex it may be, is an instrument which allows us to observe the image of the slit through which the light enters it, in the most perfect manner. If the light contains rays of every wave-length, then the images formed by each will be so close together that the spectrum will be continuous, that is, without break. If the light contains only certain wave-lengths, then we shall get certain, and not all, of the possible images of the slit, and the spectrum will be discontinuous.

Again, if we have an extremely complex light-source, let us say a solid and a mixture of gases giving us light, and we allow the light to enter, so to speak, indiscriminately into the spectroscope, then in each part of the spectrum we shall get a summation—a complex record—of the light of the same wave-length proceeding from all the different light-waves. But if by means of a lens we form an image of the light-source, so that each particular part shall be impressed in its proper place on the slit-plate, then in the spectrum the different kinds of light will be sorted out.

There is a simple experiment which shows clearly the different results obtained. If we observe the light of a candle with the spectroscope in the ordinary manner, that is, by placing the candle in front of the slit at some little distance from it, we see a band of color—a continuous spectrum—and in one particular part of the band we see a yellow line, and occasionally in the green and in the blue parts of the band other lines are observable. Now, if we throw an image of the candle on to the slit—the slit being horizontal and the image of the candle vertical—we then get three perfectly distinct spectra. We find that the interior of the candle, that is the blue part (best observed at the bottom of the candle), gives us one spectrum, the white part gives us another, while on the outside of the candle, so faint as to be almost invisible to the eye, there is a region which gives us a perfectly distinct spectrum with a line in the yellow. In this way there is no difficulty whatever in determining the coexistence of three light-sources, each with its proper spectrum, in the light of a common candle.

We see in a moment that much the same condition of affairs will be brought about if, instead of using a candle, we use an electric arc, in which the pure vapor of the substance which is being rendered incandescent fills the whole interval between the poles, the number of particles and degree of incandescence being smaller at the *sides* of the arc. We can throw an image of such an *horizontal* arc on a vertical slit; the slit will give then the spectrum of a section of the arc at right angles to its length. The vapor which exists farthest from the core of the arc has a

much more simple spectrum than that of the core of the arc itself. The spectrum of the core consists of a large number of lines, all of which die out until the part of it farthest from the center gives but one line.

In this way the spectrum of each substance furnishes us with *long* and *short* lines, the long lines being common to the more and less intensely heated parts of the arc, and the short lines special to the more heated one. This is the first step.

It has been necessary to enter thus at length into the origin of the terms long and short lines, because almost all the subsequent work which need be referred to now has had for its object the investigation of the phenomena presented by them under different conditions. The first results obtained were as follows:

1. When a metallic vapor was subjected to admixture with another gas or vapor, or to reduced pressure, I found that its spectrum became simplified by the abstraction of the shortest lines and by the thinning of many of the remaining ones. To obtain reduction of pressure, the metals were inclosed in tubes in which a partial vacuum was produced. *In all these experiments it was found that the longest lines invariably remained visible longest.*[1]

2. When we use metals chemically combined with a metalloid—in other words, when we pass from a metal to one of its *salts* (I used chlorine)—only the longest lines of the metal remain. The number is large in the case of elements of low atomic weight, and small in the case of elements of high atomic weight, and of twice the atom-fixing power of hydrogen.

3. When we use metals mechanically mixed, only the longest lines of the smallest constituent remain. On this point I must enlarge somewhat by referring to a series of experiments recorded in the "Philosophical Transactions" (1873).

A quantity of the larger constituent, generally from five to ten grammes, was weighed out, the weighing being accurate to the fraction of a milligramme; and the requisite quantity of the smaller constituent

[1] In the case of zinc the effect of these circumstances was very marked, and they may be given as a sample of the phenomena generally observed. When the pressure-gauge connected with a Sprengel pump stood at from 35 to 40 millimetres, the spectrum at the part observed was normal, except that the two lines 4924 and 4911 (both of which, when the spectrum is observed under the normal pressure, are lines with thick wings) were considerably reduced in width. On the pump being started these lines rapidly decreased in length, as did the line at 4679—4810 and 4721 being almost unaffected; at last the two at 4924 and 4911 vanished, as did 4679, and appeared only at intervals as spots on the poles, the two 4810 and 4721 remaining little changed in length, though much in brilliancy. This experiment was repeated four times, and on each occasion the gauge was found to be almost at the same point, viz.:

1st observation, when the lines 4924 and 4911 were gone, the gauge stood at 30 millimetres.

2d	"	"	"	"	29	"
3d	"	"	"	"	29	"
4th	"	"	"	"	31	"

was calculated to give, when combined, a mixture of a definite percentage composition by weight (this being more easily obtainable than a percentage composition by volume).

The quantities generally chosen were 10, 5, 1, and 0·1 per cent.

In a few cases, with metals known to have very delicate spectral reactions, a mixture of 0·01 per cent. was prepared.

Observations were then made of the spectrum of each specimen, and the result was recorded in maps in the following manner: First, the pure spectrum of the smallest constituent was observed, and the lines laid down from Thalén's map.

The series thus mapped was as follows:

Tin + Cadmium,	percentages of Cd	10, 5, 1, 0·15
Lead + Zinc,	" Zn	10, 5, 1, 0·1
Lead + Magnesium,	" Mg	10, 1, 0·1, 0·01

The observations showed that the lines of the smallest constituent disappeared as the quantity got less. Although we had here the germs of a quantitative spectrum analysis, the germs only were present, because from the existence of several "critical points," and great variations due to other causes, the results obtained were not constant.

In a subsequent research on the gold-copper alloys used in the coinage, Mr. Roberts, the Chemist of the Mint, and myself were able to show that the shortening in the length of the lines by reduced quantity was such a definite physical effect following upon reduced quantity, that a difference of $\frac{1}{10000}$ part of copper in gold could be detected.

We are now in possession of the facts utilized in the work which has led up to the subject discussed in the present paper.

They have been utilized along two perfectly distinct lines of thought:

(1) They have been used in an attempt to enable us to produce a spectrum of a substance free from lines due to the impurities which are almost always present.

(2) They have been used to indicate the existence and amount of dissociation when acknowledged compounds have been submitted to the action of different and increasing temperatures.

I will deal with (1) first.

The elimination of impurity lines is conducted as follows: The spectrum of the element is first confronted with the spectra of the substances most likely to be present to impurities. This is most conveniently done by photographing the spectra on the same plate one above the other, so that common lines are continuous.

The retention or rejection of lines coincident in two or more spectra is determined by observing in which spectrum the line is thickest; where several elements are mapped at once, all their spectra are confronted on the same plate, as by this means the presence of one of the substances as an impurity in the others can be at once detected.

Lines due to impurities, if any are thus traced, are marked for omission from the map and their true sources recorded, while any line that is observed to vary in length and thickness in the various photographs is at once suspected to be an impurity line, and if traced to such is likewise marked for omission. I give a case.

The two lines H and K (3933 and 3968), assigned both to iron and calcium by Ångström, are proved to belong to calcium in the following way:

a. The lines are well represented in the spectrum of commercial wrought iron, but are absolutely coincident with two thick lines in the spectrum of calcium chloride with which the iron spectrum was confronted.

b. The lines are represented by mere traces in the spectrum of a specimen of pure iron prepared by the late Dr. Matthiessen. Both poles of the lamp were of iron, the lower pole consisting of an ingot of the metal which had been cast in a lime-mold.

c. The lines are altogether absent in a photograph of pure iron, where both poles of the lamp were of the pure metal *not* cast in lime, and they are likewise absent in a photograph of the spectrum of the Lenarto meteorite.

By eliminating lines due to impurities in the manner just described, a spectrum is at length obtained, of which every line is assignable to the particular element photographed, the same temperature being employed in the case of all the elements observed.

With regard to the second line of work, I should commence by stating that from a beautiful series of researches carried on by several methods, Mitscherlich concluded in 1864 *that every compound of the first order, heated to a temperature adequate for the production of light, is not decomposed, but exhibits a spectrum peculiar to this compound.*

In some experiments of my own, communicated to the Royal Society in 1873, I observed:

First. That whether the spectra of iodides, bromides, etc., be observed in the flame or a weak spark, *only the longest lines of the metals are visible*, showing that only a small quantity of the simple metal is present as a result of partial dissociation, and that by increasing the temperature, and consequently the amount of dissociation, *the other lines of the metal appear in the order of their length with each rise of temperature.*

Secondly. I convinced myself that while *in air*, after the first application of heat, *the spectra and metallic lines are in the main the same, in hydrogen the spectra are different for each compound, and true metallic lines are represented according to the volatility of the compound, only the very longest lines being visible in the spectrum of the least volatile compound.*

Thirdly. I found that with a considerable elevation of temperature *the spectrum of the compound faded almost into invisibility.*

These results enable us to make the following statement:

A compound body, such as a salt of calcium, has as definite a spectrum as that given by the so-called elements; but while the spectrum of the metallic element itself consists of lines, the number and thickness of some of which increase with increased quantity, the spectrum of the compound consists in the main of channeled spaces and bands, which increase in like manner.

In short, the molecules of a simple body and a compound one are affected in the same manner by quantity in so far as their spectra are concerned; *in other words, both spectra have their long and short lines*, the lines in the spectrum of the element being represented by bands or fluted lines in the spectrum of the compound; and in each case the greatest simplicity of the spectrum depends upon the smallest quantity, and the greatest complexity upon the greatest.

The heat required to act upon such a compound as a salt of calcium, so as to render its spectrum visible, dissociates the compound according to its volatility; the number of true metallic lines which thus appear is a measure of the quantity of the metal resulting from the dissociation, and as the metal lines increase in number, the compound bands thin out.

These results bring us face to face with the subject-matter of the recent work.

First with regard to impurity elimination. I find that, although the method is good for detecting and eliminating impurities, there are still short-line coincidences between metals which are pure.

This "higher law" has come out in the following manner:

For the last four years I have been engaged upon the preparation of a map of the solar spectrum on a large scale, the work including a comparison of the Fraunhofer lines with those visible in the spectrum of the vapor of each of the metallic elements in the electric arc.

To give an idea of the thoroughness of the work, at all events in intention, I may state that the complete spectrum of the sun, on the scale of the working map, will be half a furlong long; that to map the metallic lines and purify the spectra in the manner described, more than 100,000 observations have been made and about 2,000 photographs taken.

In some of these photographs we have vapors compared with the sun; in others vapors compared with each other; and others again have been taken to show which lines are long and which are short in the spectra.

A rigorous application of the system of impurity elimination formed, of course, a large part of the work.

The final reduction of the photographs of all the metallic elements in the region 39–40—a reduction I began in the early part of last year—summarized all the observations of metallic spectra compared with the Fraunhofer lines accumulated during the whole period of observation, and all the results of the impurity elimination.

Now this reduction has shown me that the hypothesis that identical lines in different spectra are due to impurities is not sufficient. I show in detail in the paper the hopeless confusion in which I have been landed.

I find short-line coincidences between many metals the impurities of which have been eliminated, or in which the freedom from mutual impurity has been demonstrated by the absence of the longest lines.

The explanation of this result on the hypothesis that the elements are elementary does not lie on the surface, but it does on the assumption that they are compounds and behave like them.

This is the first point. We now pass from the results brought about *at the same temperature with different substances* to those observed *at different temperatures with the same substance.*

I find that when *the temperature is greatly varied*, the elements behave spectroscopically exactly as compound bodies do, as we have already seen. New lines are developed with increasing temperatures, and others fade in precisely the same way as the metallic lines made their appearance in the salts at the expense of the latter, which faded too.

In short, the observations and reasoning which I formerly employed to show how acknowledged compounds behaved in the spectroscope are now seen to indicate the compound nature of the chemical elements themselves.

In a paper communicated to the Royal Society in 1874, referring, among other matters, to the reversal of some lines in the solar spectrum, I remarked :

> It is obvious that greater attention will have to be given to the precise *character* as well as to the position of each of the Fraunhofer lines, in the thickness of which I have already observed several anomalies. I may refer more particularly at present to the two H lines 3933 and 3968 belonging to calcium, which are much thicker in all photographs of the solar spectrum (I might have added that they were by far the thickest lines in the solar spectrum) than the largest calcium line of this region (4226·3), this latter being invariably thicker than the H lines in all photographs of the calcium spectrum, and remaining, moreover, visible in the spectrum of substances containing calcium in such small quantities as not to show any traces of the H lines.
>
> How far this and similar variations between photographic records and the solar spectrum are due to causes incident to the photographic record itself, *or to variations in the intensities of the various molecular vibrations under solar and terrestrial conditions*, are questions which up to the present time I have been unable to discuss.

The progress of the work has shown that the differences here indicated are not exceptions, but are truly typical when the minute anatomy of the solar spectrum is studied.

Kirchhoff, indeed, as early as 1869 seems to have got a glimpse of the same thing, for in his memorable paper, which may justly be re-

garded as the basis of all subsequent work, he is careful to state that the sixty iron lines in the sun, to which he referred, only agree "*as a rule*" in intensity with those observed in the electric spark. Those who have given an account of his work have not always been so cautious. Indeed, I find Professor Roscoe[1] running far beyond the record in the following sentence :

> In order to map and determine the positions of the bright lines found in the electric spectra of the various metals, Kirchhoff, as I have already stated, employed the dark lines in the solar spectrum as his guides. Judge of his astonishment when he observed that dark solar lines occur in positions connected with those of all the bright iron lines! Exactly as the sodium lines were identical with Fraunhofer's lines, so for each of the iron lines, of which Kirchhoff and Ångström have mapped no less than 460, a dark solar line was seen to correspond. Not only had each line its dark representative in the solar spectrum, *but the breadth and degree of shade of the two sets of lines were seen to agree in the most perfect manner, the brightest iron lines corresponding to the darkest solar lines.*

This statement was made to prove the absolutely identical nature of the iron vapor in the sun's atmosphere and in the electric spark. As the statement is not true, the vapors can hardly be identical.

Such, then, is the reasoning on which I base the two counts in the indictment against the simple nature of the elementary bodies.

First, the common lines visible in the spectra of different elements at high identical temperatures point to a common origin. Secondly, the different lines visible in the spectra of the same substance at high and low temperatures indicate that at high temperatures dissociation goes on as continuously as it is generally recognized to do at all lower temperatures.

In my paper I attempt to show that if we grant that the highest temperatures produce common bases—in other words, if the elements are really compounds—all the phenomena so difficult to account for on the received hypothesis find a simple and sufficient explanation. And, with regard to the second count, I discuss the cases of calcium, iron, lithium, and hydrogen. I might have brought, and shall subsequently bring, other cases forward. In all these I show that the lines most strongly developed at the highest temperatures are precisely those which are seen almost alone in the spectra of the hottest stars, and which are most obviously present in the spectrum of our own sun. Now, if it be true that the temperature of the arc breaks up the elements, then the higher temperature of the sun should do this in a still more effective manner. Here, then, we have a test.

I have put this question to the sun, and I have sent in a second paper to the Royal Society embodying a preliminary discussion of Professor Young's work at Sherman, Tacchini's observations, and my own. In this paper I state my grounds for the belief that all the solar phe-

[1] "Spectrum Analysis," third edition, p. 240.

nomena we have been watching with our spectroscopes for the last ten years can not be explained on the existing hypothesis, and that they are simply and sufficiently accounted for by supposing that primordial atoms are associated in the corona and dissociated in the reversing layer.

In this way the vertical currents in the solar atmosphere, both ascending and descending, the intense absorption in sun-spots, their association with the faculæ, and *the apparently continuous spectrum of the corona*, and its structure, find an easy solution.

We are yet as far as ever from a demonstration of the cause of the variation in the temperature of the sun; but the excess of so-called calcium with minimum sun-spots, and excess of so-called hydrogen with maximum sun-spots, follow naturally from the hypothesis, and afford indications that the temperature of the hottest region in the sun closely approximates to that of the reversing layer in stars of the type of Sirius and *α* Lyræ.

EXPERIMENTS WITH LIVING HUMAN BEINGS.[1]

By GEORGE M. BEARD, M. D.

I.

MR. JOHN STUART MILL, in the preface to his work on "Logic and the Principles of Evidence," observes that while in the search for truth we may be able, in some cases, to avoid errors instinctively and successfully, although unable to formulate the method by which we do so, yet it is an advantage not to be dispensed with to have a rational understanding of the philosophy of reasoning, so that we shall not be forced to depend alone on blind and irregular instinct.

In experimenting with *living* human beings there are *six* sources of errors which instinctively physiologists and physicians sometimes guard against and allow for, but which ought to be and can be, as I contend, and shall here aim to prove, reduced to a positive science. As these elements of error come in the main from the nervous system, their study belongs preëminently to neurology, or the study of the nervous system in health and disease; and it is because of the backwardness of this specialty that the subject has been thus far passed by.

The deficiencies of our knowledge of this subject were forced on

[1] An abstract of a portion of this paper was read before the American Neurological Association at New York, June, 1878. This essay relates to questions suggested in my series of papers on "The Scientific Study of Human Testimony," published in the May, June, and July (1878) numbers of the "Monthly," and may be of service to those who are interested in that subject. This department of science is of especial interest at the present time, when the experiments of Charcot and the criticisms upon them are exciting so much attention.

my attention several years ago, when I was engaged in the study of the physiology of mind-reading, and making experiments in mental therapeutics; and in essays published on those topics I briefly noted these errors, which I was obliged to study out, and without any theoretical guide or precedent. I found that the whole matter—the importance and interest of which were of the very highest, practically as well as scientifically—was as unexplored as central Africa, and that it was necessary to hew one's way clear of infinite obstructions at every step.

From the elevation of this subject to a positive science these two practical benefits must flow:

1. The world will be spared the reports of such experiments as those of the physician who examined into the condition of the hysterical girls that were the cause of the Salem witchcraft epidemic, and of the committees of the French Academy, of Gregory and of Elliotson and others, with clairvoyance and mesmeric trance; of Crookes with Home, of Wallace and Zöllner with Slade, and, latest of all, of Parkhurst and others with Mollie Fancher; of Charcot, Westphal, and their coadjutors with metalloscopy and metal-therapeutics; and will at the same time be able to reach the solid truth that lies behind all such accredited phenomena. These experiments and these reports are often made by strong and earnest men; indeed, the abler the experimenter in the present state of the subject, the worse his experiments and his reports of these experiments: instead of arriving at the truth of many questions of physiology, we get farther and farther from it the more we study them.

2. There will be more precision to all our investigations in regard to the action of remedies, and especially of new remedies. At the present time we know not whether to believe or reject any report of the virtues of any new medicine or mode of treatment, however high the authority for the reports, for we feel instinctively the elements of error which those who introduce new remedies and modes of treatment ought to know, and in time will know and rationally provide for.

3. Men of narrow or but limited ability will be able to attain accurate results in experimenting with living human beings where now the strongest scientific geniuses of the world are every day failing abjectly and humiliatingly. Sir William Hamilton, in his work on "Logic," remarks most truly that the proud boast of Bacon that, by the system of inductive philosophy, it would be possible for ordinary men to make discoveries in science, has been strictly fulfilled: every day under the light of the inductive method very commonplace minds are finding new and important facts that go to swell the current of science. Genius of the first order is rare, and in every field of knowledge the details of cultivation must be worked out by the average man; the bulk of the work is done, always has been done, and probably always will be done, by talent rather than by genius.

The elements of error in experimenting with *inanimate* objects were indicated, in a general way, by Bacon, under the strange headings "Idols of the Tribe," "Of the Den," "Of the Forum," "Of the Theatre"; and later writers on evidence and the principles of science have repeated or assumed the Baconian formulas; but the special elements of error in experimenting with *living* human beings have escaped conscious and exhaustive analysis. To have formulated these elements of error much sooner than the present time would have been quite impossible, for our knowledge of the involuntary life—one of the most important factors—was far too limited.

The science and art of experimenting with living human beings is indeed now in precisely the same state as the general philosophy of induction prior to the time of Bacon. Before the era of the Baconian philosophy, indeed in all eras, men had *instinctively* employed the inductive method, but the principles of that method had never been formulated; consequently, when philosophers reasoned or attempted to reason on the subject, they almost always went wrong. The philosophy of Bacon applies only to *inanimate* nature; of the art of seeking truth through experiments on *living* human beings—of the *six* sources of error in all such experiments and the means of guarding against them—he knew nothing, and evidently suspected nothing; and that branch of philosophy—of such vast import in biological investigations—has remained to this day unstudied and almost unthought of; hence, although some experimenters are saved through their instincts, others—and those the very ablest scientific geniuses of the age—never attempt to reason on the subject without falling into serious error.

In experimenting with living human beings there are, as above stated, just *six* sources of error, all of which are to be recognized and systematically and, if possible, also simultaneously guarded against if our results are to command the confidence and homage of science. To be guilty of overlooking, in any research, even one of these six possibilities of error, is to be guilty of overlooking all, and practically to vitiate all the results of our labors.

These six sources of error are as follows:

First Source of Error: *The phenomena of the involuntary life in both the experimenter and the subject experimented on.*—Under this head are embraced trance, with all its manifold symptoms, and all the interactions of mind and body that are below the plane of volition or of consciousness or of both. Without a knowledge of this side of physiology, scientific experimenting with living human beings is impossible. It is a want of this knowledge that makes most of the experiments of scientific men in this department during the past century so unsatisfactory and so ludicrous.

Second Source of Error: *Unconscious deception on the part of the subject experimented on.*—This unconscious deception comes

through the involuntary life—the mind of the subject acting on the body—and producing results which, it is to be noted, are as decided, as uniform, and as permanent as when produced by powerful objective influences. This element of error slips into all the ordinary experiments with new remedies and supposed new forces in the animal body, thus corrupting science at its very sources. The neglect of this element of error would of itself, even though all the other errors were guarded against, destroy entirely the scientific value of all such experiments, for example, as those of the committees of the French Academy with clairvoyants and mesmerism; it is because physicians of experience instinctively feel this element of error, that reports of cases wrought by novel and strange and especially by imposing methods of treatment are so frequently discredited. Under this head come also all the so-styled miracles of healing, whatever may be the paraphernalia through which they are accomplished.

I know not where can be found a better single illustration of the effect of this element of error, alone of itself, in scientific research, when all the other elements of error seem to be provided for, than in the experiments on animal magnetism of the late Dr. J. K. Mitchell, as recorded in the volume of his miscellaneous writings. Dr. Mitchell was an original thinker, an observer of patience and care, and a clear and logical writer, who suggested more than he told, and his chapter on animal magnetism was incomparably the best essay ever written on that subject down to the date of its publication. This paper—which consisted of a record of independent, careful, and many times repeated experiments on living human beings, with remarks thereon—shows that the author not only had the courage and the power to do his own thinking and experimenting, but that he recognized some of the chances of error in experiments of this kind, and fortified himself against them; while of the errors that enter through the doors of the involuntary life—the unconscious deception of the subject experimented on—he knew, and apparently suspected, little. His essay is therefore at once a model and a warning: a model for thoroughness and precision up to a certain point, or within a limited area; a warning as demonstrating the worthlessness of all experiments with human beings when any one or two of the six sources of mistake are overlooked. So accurate and scientific were these experiments, in certain directions, that they have furnished an important contribution to our knowledge of some of the symptoms of mesmerism, in spite of the fact that the author failed, like hundreds of able men in science before him, to solve the problem of the nature of trance. By not understanding and taking into account the phenomena of the involuntary life, of which in his day very little was known, and of trance, of which nothing was known, this acute and philosophic observer allowed the subjects on whom he operated to constantly deceive themselves and deceive him, and to drive him to the logical but absolutely false conclusion that the mesmeric trance was an

objective state induced by a supposed fluid, or force, or influence, then and now known as animal magnetism.

In order to be able always to guard effectively and absolutely against these two sources of error that I have thus far specified, just two things are necessary for the experimenter:

1. A general knowledge of the phenomena of the involuntary life, including both the action of mind on body and of body on mind, in health and in disease, and especially of the real nature and philosophy of trance, the state in which the involuntary life culminates.

2. The subject experimented on must always be *deceived* in the experiments in such a way that this involuntary action of his mind or body can not come in and destroy the experiment. The subject may be successfully deceived in three different ways, which I shall presently specify.

Burq, Charcot, Westphal, and their coadjutors in the now well-known metalloscopy experiments, failed on both of these points. Many of the critics of those experiments, as Althaus, Reynolds, and other physicians in England, also failed to comprehend these points, hence the inconsistency and unsatisfactoriness of the discussions to which these experiments gave rise. The claim of Burq and Charcot and Westphal in regard to the temporary relief of hysterical and sometimes of organic anæsthesia by the local application of metals might be entirely true, but thus far they have failed, in a scientific sense, to prove it to be true. I do not deny their results—indeed, there is a possibility that some of them may be genuine—although in my own experience with the same method I fail to confirm their claims; it is in the manner in which the experiments were conducted, without regard to the results, that the non-expertness of these experimenters appeared. The criticism I have to make on Charcot is that, in his elaborate lectures on this subject, he nowhere gives evidence of a full appreciation of the power of the involuntary life, particularly in hysterical conditions, or of the true and only method of systematically and successfully guarding against it. The experiments now going on under the same superintendence in the hospital of Salpêtrière with mesmeric trance, and with the effects of magnets and lights on catalepsy and kindred conditions, are all open to the same criticism.

If some savage fresh from the jungles were put on board of an engine, and told how to open the valves, he might very naturally infer that his own feeble strength caused the train to move; in like manner, scientific experimenters with living human beings attribute the phenomena that follow the application of metals and magnets and passes and flummeries solely to the objective influence of these appliances, whereas in truth these and similar performances but serve to let on the potent forces of the subject's own mind. The mistake of these philosophers is indeed quite analogous to that of the little boy who,

when placed on the front seat of the carriage, pleases himself with the fancy that he is guiding the horse, when all the time his strong father behind him is quietly holding and pulling the reins. In all experiments with living human beings, as in the special branch that we call therapeutics, it is oftentimes not what we do, but *how* we do it, that determines the results.

As regards this first point—the action of mind on body—I may say that, by a series of experiments not yet published, but a brief abstract of which has been twice presented to this Association, it has been proved that, by properly turning the mind of the patient on his body, through excitations of the emotions of wonder and special expectation, it is possible not only to relieve for the time various functional diseases, but in many instances to *perfectly* and *permanently cure* them; and it was also shown that *organic* or *structural* diseases may be relieved in the same way, in some cases, more satisfactorily than by any objective medical treatment whatever. The method by which the emotions are to be acted upon for the purposes of mental therapeutics are now so far organized into a science that any one who will make himself practically familiar with the subject can obtain the same results. The first mistake of Charcot and his coadjutors in France, and his followers in England and in Germany, was in assuming that such effects as the orderly, uniform reappearance of the sense of the different colors in hysterical women, and the symmetrical transference of sensory phenomena from one side of the body to the other, under the local application of metallic disks in hemianæsthesia, could not be produced *subjectively* by the mind of the patient. Such an assumption would never have been made by any one who had performed or witnessed the experiments in mental therapeutics of which I have spoken; for, again and again, not only in hysteria, but in other forms of disease, and in conditions not distinctively nervous, I have obtained results which, in definiteness, in quantity, and in permanence, are far more imposing, proving beyond question that, when all the sources of error were considered and provided for, the results were entirely independent of any objective power in the means employed—were, in short, subjective purely; applications of metals, or wood, or paper, or no applications at all, provided the subject expected them, being equally effective.

Science is not a matter of opinion; its very essence is demonstration; and the question whether, in any given experiments, the results are subjective or objective, can be brought entirely out of all discussion and all opinion, provided the elements of error are understood and avoided. Indeed, all discussion in scientific matters must be, in logical strictness, unscientific: if we know anything, there may be need for statement, of explanation, of illustration, but none for discussion; if we do not know, the course of wisdom is to keep silence until we do. With the formulated six sources of error before them, and the methods of protecting themselves against them, the experiments of Charcot

would never have been discussed, even for a moment, in any scientific body.

The *three* methods of deceiving the subject by which alone the element of error from mind acting on body can be eliminated, and the results of experiments with living human beings transferred from the realm of opinion to science or positive knowledge, are these:

1. By doing something when the subject experimented on believes that we are doing nothing.

2. By doing nothing when the subject believes that we are doing something.

3. By doing something different from what the subject believes is being done.

In experiments of importance, as where radical and overwhelming discoveries in science are claimed to be made, *all* of these methods of deceiving should be used; and it is because they are not used in the experiments of scientific men that we are constantly compelled to face and listen to the claims of "animal magnetism," of "odic force," of "spiritism," of "cundurango," of "blue glass," and, during the past year, of "Mollie Fancher," of "metalloscopy," and "metal-therapeutics."

A classical example of one method of deception in experiments of this character was afforded by the *exposé* of the performances of mesmerized or professedly mesmerized girls by Mr. Wakley, of the London "Lancet." A good example of neglect of this deception, as well as of ignorance of the relation of mind to body, is found in the experiments of Dr. Vansant with magnets, as published by him a few years ago. This writer gives an immense number of differential symptoms that, as he claims, are produced by the north and south poles of the magnet; his experiments were in the same line with the famous Perkins tractors, though apparently more scientific; the same criticism applies to the researches that are now being made in the Salpêtrière Hospital in Paris, where, according to the testimony of experts who have witnessed them, and the statements of the experimenters themselves, no systematic deception is employed or even suggested.

That even the strongest leaders in physiology are not fully armed against the errors that beset experimental research, when living human beings are the subjects, is shown in the not long ago published Lowell Lectures of Professor Brown-Séquard, wherein that master in experimental study through the processes of vivisection declares that the claims of telling of time through the back of the head are authentic. Deductive reasoning for ever disproves this claim, which any inductive research, properly conducted, must always confirm; but any test to be of value must, at every step, shut out absolutely all the six avenues of error; and the report of any test, in order to be worth reading, must clearly state and show that all such errors were so excluded.

Experiments in physics are likewise, in some instances, complicated with experiments with living human beings. Thus in the "Keely motor" and "Winter motor" claims, and in other like devices for the overthrow of the law of the conservation of energy, the apparatus for generating power was in the hands of interested non-experts, who might be capable of either willful or self-deception—for the purposes of science it matters not which—and no satisfactory experiment could be made unless these possibilities of error could be eliminated.

The temporary success of cundurango was almost entirely the result of self-deception of those who, under the mingled emotions of hope, despair, and expectation, availed themselves of it. It is impossible to introduce any drug or system of treatment for cancer, or any other grave disorder, amid great pomp and noise, and under the patronage of honored names, without at least relieving, for the time, a certain proportion of cases; and practically it is of little import what the drug or remedy may be, if only the confidence of the sufferers is assured.

Men not only of general but of special experimental ability are constantly going far out of the way in scientific research through want of simple knowledge of the laws and phenomena of the involuntary life—a branch of physiology which, though of extreme interest and overflowing in suggestion, is so young and recent in its development that it is not yet taught in colleges or schools. The published monographs of the late Mr. Braid, of Manchester, show indisputably that their author was not without a certain genius for scientific research; but in all his philosophizing on the effects of fixed attention and straining of the eyes in the production of what has been known as hypnotism he missed utterly the discovery, or even the suspicion, of the great fact that trance, of which hypnotism is but one of numberless phases, was a subjective not an objective condition—existing in the subject's own brain—and that the manœuvrings by which he was wont to excite it were but one of infinite devices for acting upon the mind; thus Mr. Braid failed to solve the problem of trance. Similarly Professor Czermak—one of the inventors of the laryngoscope—though he made many experiments in the production of hypnotism in animals, likewise confounded the subjective with the objective, and did not arrive at the true explanation of his own experiments. Indeed, from the time of Mesmer down, all or nearly all the scientific studies and attempted scientific studies of trance, in any of its multiform phases, have been made valueless by this same non-recognition of the involuntary life, of which trance is the extreme expression. Confounding the subjective with the objective vitiates nearly all human philosophy.

Similarly Mr. Edison, in his experiments with those highly interesting phenomena that he supposes to indicate a new force, was so far misled by the muscular contractions of the tongue when applied to a block of iron, through which the suspected force was passing, as to conclude that an objective influence was acting, whereas, after the ele-

ment of error from the expectation of the experimenter was eliminated, it was quickly shown that the contractions were entirely subjective. Mr. Edison, I may say, is not only an inventor of phenomenal genius, but likewise a skilled and practiced experimentalist, and, as I found when making these and similar investigations with him, extraordinarily fertile in resources of method and device for wresting the secrets from nature, and usually alert against subtile sources of error ; but, when drawn into the province of the involuntary life, he found himself, like men of science in general, insufficiently equipped with knowledge to even surmise, not to say provide for, the errors that may arise from the unconscious or involuntary action of mind on body.

In some instances the reverse mistake is made, and phenomena of the involuntary life are supposed to be volitional. In the case of the "Maine jumpers" or so-called "jumping Frenchmen" of Canada and the Maine woods—the incredible performances of which I have elsewhere described—it had for years been assumed, both by men of science and by the laity, that the movements were intentional, and within control. This conclusion, though most erroneous, was quite a natural one for those who have no knowledge of the relation of mind to its physical substratum.

An illustration of the second method of deception—doing nothing when the subject supposes we are doing something—is professing to apply electricity, putting the electrodes in position, and going through the motions, when no current is running, or when the connection is broken ; in this way I have several times proved that patients were mistaken in inferring that electrical applications injured them; and, conversely, I have been able in one striking case to prove that the patient was right, and that a certain symptom was temporarily aggravated by the application.

Third Source of Error : *Intentional deception on the part of the subject.*—This element of error is so obvious that it would seem to be quite needless to refer to it ; and yet it is constantly overlooked even in researches conducted by physiologists. To assume, as is often or usually done, that the subject on whom the experiment is made is honest in his relation to that experiment, because he has a general character for honesty, is always unscientific; and all experiments where such assumption is made must be ruled out of science.

Intentional as well as unintentional deception on the part of the subject can only be scientifically met by deception on the part of the experimenter. The methods of deceiving already described suffice to guard against all deception on the part of the subject, whether intentional or unintentional.

It is clear proof of the non-expertness of Zöllner, Wallace, Charcot, and Westphal, that in their published accounts of experiments with living human beings they assumed that, if the subjects were honest, the

results of the experiments must be accepted by science. Scientifically it makes no difference whether the subject on whom any such experiment is performed is honest or dishonest; the experiments are to be made without any reference to the moral character of the subject.

FOURTH SOURCE OF ERROR: *Unintentional collusion of third parties.*—By third parties are meant audiences, witnesses, bystanders, or assistants seen or unseen.

The best illustration of error from this source is the aid which audiences in the mind-reading experiments give to the performer by their silence, when he wanders away from the object looked for, and by their murmurs and applause when he approaches or reaches it. This is quite analogous to the cry of "hot" or "cold" in the game of "blind-man's-buff." So natural is it for errors from this cause to enter these investigations that I found it necessary, in all my researches in that department, to send all witnesses from the room, or to insist on their being absolutely silent, and even motionless, at every stage of the experiments.

FIFTH SOURCE OF ERROR: *Intentional collusion of third parties.*—Under this head comes the aid which assistants, known or unknown, *designedly* give to the subject experimented on. This, in the abstract, is one of the more readily suspected of all the six sources of error, but in the concrete very difficult to guard against, or even to detect, as is so brilliantly illustrated in the conjuring tricks of Houdin and Heller, and, it may be added also, in the operations of so-called "confidence-men."

The best and most mystifying tricks of illusionists, and sleight-of-hand performers of all kinds, are almost always done through some form of collusion, the time and method of which are so artfully arranged that only those of unusual acuteness or expert skill can at once detect them. The astounding success of clairvoyants and mediums in telling people what they already know, but which they suppose can not be known to the witch they are consulting, is oftentimes explained by this fifth source of error.

Intentional, deliberate deception, where no money is to be gained by deception, is much more common among the better classes than those who have not specially studied this subject would be willing to believe: it is an instructive fact in the psychology of lying, that some persons—usually, though not always, women—whose general character is of the highest, are in some special direction absolutely systematically untruthful all their lives long. An old merchant of New York once told me that a clerk in his employ, trustworthy in all business affairs, exact, scrupulous, just, had a habit of telling large stories in regard to what he had seen and done so firmly fixed that it was organically impossible for him to restrict himself to the facts, and that his statements in regard to matters outside of business were worthy of absolutely no credence.

I was once requested by a valued medical friend to aid him in some experiments with a case of alleged sixth sense, or the asserted power of

reading without the use of the eyes. The subject who made the claim was a lady of education, culture, and social position, universally and justly respected. In answer to the request, I stated that by deductive reasoning it was established as firmly as the Copernican theory, or the law of the persistence of force, that no human creature could have any such power, and that therefore it would be unscientific to investigate any such claim ; but as an amusement, and for the sake of determining whether the deception was intentional or unintentional, I would suggest and prepare some tests in which all the six sources of error would be excluded. This was done. The tests were of course not taken, but the result of the investigation was to demonstrate the interesting psychological fact that for years a graceful and agreeable lady had been deceiving not only strangers and friends, but even her own husband, by means of the very old and familiar "ballot-trick," and a not especially adroit method of performing it. The puzzling cases of starving girls, of invalid clairvoyants, of mediumship, that are constantly infesting and astonishing civilized society, are in many instances to be similarly explained. The "mind-readers" were originally self-deceived, since the physiological interpretation of that phenomenon is too complex and profound to be suggested, not to say comprehended, by the mass of those who are accustomed to practice that art. But at the present time the public performers probably understand, in a general way, the philosophy of their success, at least enough to know that their claims of a sixth sense are baseless.

Lying, like stealing, may become a passion, and, in like manner also, may concentrate all its force in some one direction, for folly as well as wisdom has its specialties and hobbies : there is a monomania for deceiving, where naught is gained save its own gratification ; one who is in all other directions honorable and just may become an inebriate of falsifying, and be half his days intoxicated thereby.

ATHEISM AND THE CHURCH.

BY REV. G. H. CURTEIS.

OMNIA EXEUNT IN—THEOLOGIAM.[1] No branch of science appears to consider itself complete, nowadays, until it has issued at last into the vexed ocean of theology. Thus, Biology writes "Lay Sermons" in Professor Huxley ; Physics acknowledges itself almost Christian in Professor Tyndall ; Anthropology claims to be religious in Mr. Darwin ; and Logic, in Mr. Spencer, confesses that "a religious system is a normal and essential factor in every evolving society."[2]

[1] Everything issues into theology.

[2] Spencer, "Sociology" (seventh edition, 1878), p. 313.

It is only the second-rate men of science who loudly vaunt their ability to do without religion altogether, and proclaim their fixed and unchangeable resolve for its entire suppression. As well resolve to suppress the Gulf Stream or the eccentricity of the earth's orbit! If the horizon of man's thought is bounded on all sides by mystery, it is in simple obedience to the law of his nature that he gives some *shape* to that mystery. It were mental cowardice to shrink from facing it; it were positive imbecility to declare that the coast-line between known and unknown had no shape at all. Granted that the line be a slowly fluctuating one, and that conquests here and losses there reveal themselves in course of time, and one day become "striking" to the commonest observer, does that fact acquit of folly the Agnostic statement that, now and here, there is no thinkable line at all, no features to be described, nothing to sketch, no appreciable curves and headlands, no conception possible which shall integrate (for practical utility) that great Beyond whose boundaries, on the hither side at least, are known to us? Men who can only attend to one thing at a time, and whose "one thing" is the field of a microscope or "the anatomy of the lower part of the hindmost bone of the skull of a carp,"[1] may perhaps escape the common lot of manhood by ceasing to be "men," in any ordinary sense of the word. But, for people who live in the open air and sunshine of common life, there is the same necessity for a religion as there is for that mental map of our whereabouts that we all carry with us in our brains. Let any one recall his sensations when he has at any time been overtaken in a fog or a snow-storm, and when all his bearings have been blotted out, then he will readily understand the need which all men feel for a theology of some kind, and he will appreciate what the old-school divines meant when they said that "Theology was the queen and mistress of the sciences," harmonizing and gathering up into architectonic unity all the multifarious threads that the subordinate sciences had spun.

I. One is driven, nowadays, to repeat both in public and private these very obvious reflections, owing to the extraordinary persistence with which certain philosophers think fit to inform us that we are all making a great mistake; that we can do very well without a religion; and that, though it is true "man can not live by bread alone," but must have *ideas*, yet the creed by which he may very well make shift to live is this—"SOMETHING IS."[2] In point of brevity there is here little to desire. The Apostles' Creed is prolix by comparison, and although we might fairly take exception to "some-thing," as embodying two very concrete acts of the imagination, and therefore capable

[1] Cf. Mivart, "Contemporary Evolution" (1876), p. 134.

[2] Physicus, "Examination of Theism" (1878), p. 142: "What was the essential substance of that [atheistic] theory? Apparently it was the bare statement of the unthinkable fact that Something Is. The *essence* of atheism I take to consist in the single dogma of self-existence as itself sufficient to constitute a theory of things."

of further logical "purification," it were ungenerous to press the objection too far. This creed is purer than that of Strauss: "We believe in no God, but only in a self-poised and, amid eternal changes, constant universum."[1] It is wider than that of Hartmann: "God is a personification of force."[2] It is simpler than that of Matthew Arnold: God is "a power, not ourselves, that makes for righteousness."[3] It is more intelligible than that of J. S. Mill: "A Being of great but limited power, how or by what limited we can not even conjecture"—a notion found also in Lucretius and in Seneca.[4] It is more theological than that of Professor Huxley: "The order of nature is ascertainable by our faculties, and our volition counts for something in the course of events."[5] It is similar to that of the ancient Brahmans: "That which can not be seen by the eye, but by which the eye sees, that is Brahma; if thou thinkest thou canst know it, then thou knowest it very little; it is reached only by him who says, 'It is! it is!'"[6] And considering that this formula is very nearly what is said also by the Fathers of the Church, what better *formula concordiæ*[7] between science and theism could we require? For instance, Clemens Alexandrinus (A. D. 200) echoes St. Paul's "Know Him, sayest thou! rather art known of him," with the confession, "We know not what he is, but only what he is not"; Cyril of Jerusalem (A. D. 350) says, "To know God is beyond man's powers"; St. Augustine (A. D. 400), "Rare is the mind that in speaking of God knows what it means"; John of Damascus (A. D. 800), "What is the substance of God or how he exists in all things, we are Agnostics, and can not say a word"; and in the middle ages, Duns Scotus (A. D. 1300): "Is God accessible to our reason? I hold that he is not."[8]

It seems, then, there is a consensus among all competent persons, who have ever thought deeply on the subject, that the real nature of that Power which underlies all existing things is absolutely unknown to man. And it is allowable, therefore, in the last resort, to fall back upon Spinoza's word "sub-stance"; and to accept—if charity so require—as the common basis for theological reunion, the Agnostic formula, "Something Is."

But then, unless some means be found for instantly paralyzing the restless energy of human inquiry, the next question is inevitable: *What* is that Something? What are its qualities, its attributes?

1 Strauss, "Der alte und der neue Glaube" (fourth edition, 1873), p. 116.

2 Hartmann, "Gott und Naturwissenschaft" (second edition, 1872), p. 14.

3 M. Arnold, "Literature and Dogma," p. 306.

4 J. S. Mill, "Essays on Religion," p. 124. Cf. Lucretius, vi., and Seneca, Nat. Qu. i. 1.

5 Huxley, "Lay Sermons."

6 The "Upanishad": *ap.* Clarke's "Ten Great Religions," p. 84.

7 Formula of agreement.

8 Gal. iv. 9; Clem. Alex., Strom. v. 11; Cyr. Jer., Cat. Lect. xi. 3; Aug., Confess. xiii. 11; Joh. Dam., De Fide Orthod. i. 2; Duns Scotus, In Sent. i. 3. 1.

How are we to conceive of it? Given (in Aristotelian phrase) its *οὐσια*,[1] what is its *ποιότης*,[2] its *ποσότης*,[3] and the rest, which go to make up its idea? "Existence" is, after all, only one of our three necessary forms of thought: "Space" and "Time" are also necessary to our thinking. And it is in vain for pure logicians to put on papal airs, to forbid the question, to cry *Non possumus*,[4] and to stifle all free thinking. It is useless to say: "We have already, with razors of the utmost fineness, split and resplit every emergent phenomenon; we have, by assiduous devotion to the one single and undisturbed function of analysis, examined every possible conception that man can form, and have discovered everywhere compound notions, ideas that are 'impure' and capable of further logical fissures: salvation is only possible by the confession that 'Something Is'; there rest and be thankful!" It is all of no avail. *Naturam expellas furca*[5]—she is sure to return in armed revolt, and to demand, Who told thee that thou wast thus nakedly equipped? Reason is one thing; but imagination is also another. If analysis is a power of the human mind, so also is synthesis. If you can not think at all without using the one, neither can you without employing the other. Take, for instance, a process of the "purest" mathematics—"twice six is twelve"; you were taught that probably with an abacus, and the ghost of the abacus still lingers in your brain. "The square of the hypotenuse": you saw that once in a figured Euclid, and you learned thereby to form any number of similar mental figures for yourself. No: you may call the methods by which mankind think "impure," or attach to them any other derogatory epithet you please; but mankind will deride you for your pains, and will reply: "The philosopher who will only breathe pure oxygen will die; he that walks on one leg, and declines to use the other, will cut but a sorry figure in society; he that uses only one eye will never get a stereoscopic view of anything. Use, man, the *compound* instrument of knowledge your nature has provided for you, and you will both see and live." Why, even so determined a logician as "Physicus" is obliged sometimes to admit that "this *symbolic* method of reasoning is, from the nature of the case, the only method of scientific reasoning which is available."[6] And Professor Tyndall, in the November number of another Review, after complaining that "it is against the mythologic scenery of religion that Science enters her protest," finds himself also obliged to mythologize; for he adds (seven pages further on): "How are we to *figure* this molecular motion? Suppose the leaves to be shaken from a birch-tree, . . . and, *to fix the idea*, suppose each leaf," etc. And so Professor Cooke writes:

I can not agree with those who regard the wave-theory of light as an established principle of science. . . . There is something concerned in the phenomena of light which has definite dimensions. We *represent* these dimensions to our

[1] Essence. [2] Quality. [3] Quantity. [4] We can not.
[5] Put nature out with a pitchfork. [6] "Examination of Theism," p. 84.

imagination as wave-lengths, and *we shall find it difficult to think clearly* upon the subject without the aid of this wave-theory."[1]

In short, it is obvious that without the help of this mythologic, poetic, image-forming faculty, all our pursuit of truth were in vain. And therefore, starting from the common basis of a confession that "something is," we are more than justified, we are obeying a necessary law of our nature, in asking WHAT that eternal substratum of existence is, and with what morphologic aid the imagination may best present it for our contemplation.

But here the pure logician may perhaps retort: "You forget that the conceptions men form of things are, at their very best, nothing more than human, and therefore *relative* conceptions. A fly or a fish probably sees things differently. And an inhabitant of Mercury or Saturn might form a conception of the universe bearing little resemblance to yours."[2] Quite true; but logicians there, too, would probably be heard to complain that, colored by Saturnian or Mercurian relativities, truth was sadly impure, and was, in fact, attained by no one but themselves. Nay, in those other worlds priests of Logic might be found so wrapped in superstition as to launch epithets of contempt on all who approached to puncture their inflated fallacies, and who devoutly believed that a syllogism did *not* contain a *petitio principii*[3] neatly wrapped up in its own premises, and an induction was *not* an application of a preëxisting general idea, but a downright discovery of absolute truth. If from such afflictions we on earth are free, it is because the common sense of mankind declares itself serenely content with the relative and the human; because, while fully aware (from our schoolboy days) that all our faculties—reason among the rest—are limited and earthly, we have faith that "all is well" in mind, as it certainly is in matter; and because we smile at the simplicity of our modern wranglers, who can only analyze down as far as "SOMETHING," when their Buddhist masters two thousand years ago had dug far deeper, viz., to NOTHING:

> The mind of the supreme Buddha is swift, quick, piercing, because he is infinitely "pure." Nirwana is the destruction of all the elements of existence. The being who is "purified" knows there is no Ego, no self; all the afflictions connected with existence are overcome, all the principles of existence are annihilated, and that annihilation is Nirwana.[4]

The Churchman, therefore, holds himself so far justified in claiming

[1] Cooke, "The New Chemistry" (fourth edition, 1878), p. 22.

[2] "Physicus" (p. 143) rides this logical hobby far beyond the confines of the sublime. He demands of the theist to show that his "God is something more than a mere causal agent which is 'absolute' in the grotesquely restricted sense of being independent of one petty race of creatures with an ephemeral experience of what is going on in one tiny corner of the universe."

[3] Begging the question.

[4] Hardy, "Eastern Monachism," p. 291.

the modern atheist as his ally. They are at least traveling both together on the high-road which leads from a destructive nihilism toward a constructive religion. Only the atheist has thought it his duty to go back again to the beginning, and to measure industriously the same ground that the Church had gone over just two thousand four hundred years ago, when the great "Something is" addressed itself to man through Moses in the word "I am," or Jehovah (יהוה, Absolute Existence).[1]

But perhaps the pure logician may attempt another reply. Finding us not in the least disconcerted by hearing, once again, the familiar truth that all our faculties are limited, he may attempt to shatter our serenity by an announcement of a more novel kind. He may say: Not only is the imagery with which you clothe, represent, and conceive the Self-existent merely relative and human, but—far more damning fact—it is all a development. It has all grown with the growth of your race. Environment and heredity have supplied you with all your forms of thought. Even your "conscience is nothing more than an organized body of certain psychological elements which, by long inheritance, have come to inform us by way of intuitive feeling how we should act for the benefit of society."[2]

Be it so. The proof has not yet been made out. But since these evolution doctrines are (as Dr. Newman would say) "in the air," it is more consonant to the ruling ideas which at present dominate our imagination to conceive things in this way. Indeed, to a large and increasing number of Churchmen the evolution hypothesis appears, not only profoundly interesting, but probably true. They find there nothing to shake their faith, and a good deal to confirm it. Man is what he is, in whatever way he may have become so. And how atheists can persuade themselves that this beautiful theory of the divine method helps their denial of a deity, the modern school of theologians is at a loss to understand. For the cosmic force whom Christians worship has, from the very beginning, been represented to them, not as a fickle, but as a continuous and a law-abiding energy. "My Father worketh hitherto," said Christ. "Not a sparrow falleth to the ground" without his cognizance. "The very hairs of your head are all numbered." "In Him we live and move and have our being." Pictorial expressions, no doubt. But what words could more clearly indicate the unbroken continuity of causation in nature than these texts from the Christian Scriptures? And it is surely the establishment of a continuous, as distinct from an intermittent, agency in nature which forms the leading point of interest both to science and to the Church, at the present day, as against a shallow deism. If, therefore, man's imaginative and moral faculties, as we know them now, are a development from former and lower—yes, even from savage, from bestial, from material—antecedents, what is that to us? Of man's logical powers the self-same thing has to be said. Why,

[1] Exodus vi. 3.

[2] "Physicus," p. 31.

then, should Logic give itself such mighty airs of superiority and forget its equally humble origin? How does it affect the truthfulness in relation to man, and the trustworthiness, for all practical purposes, of our image-forming faculties, that it is what it is only after long evolution, and that the race had a fœtal period as well as the individual?

The upshot, then, of the whole discussion is surely this: The Absolute is confessedly inconceivable by man. All our mental faculties are in the same category: they are all finite, relative, imperfect. But then they are suited to our present development and environment. Faith in them is therefore required, and a bold masculine use of them all. For in nature, as in grace, "God hath not given us the spirit of fear, but of power and of love and of a sound mind."[1] If, then, there are questions into which mere analytic reasoning can not enter, if Logic is powerless, for instance, before a musical score, and is struck dumb before the self-devotion of Thermopylæ, or the unapproachable self-sacrifice of Calvary, by what right are we forbidden to employ these other faculties which help us, and whose constructive help brings joy and health and peace to our minds? The many-colored poetical aspect of things is, assuredly, no less "pure" and far more interesting than the washed-out and colorless zero reached by interminable analysis. The colored sunlight is no less "pure," and it reveals a great deal more of truth, than "the pale moon's watery beams." And so we venture to predict that a constructive Christianity which, *πολυμέρως καὶ πολυτρόπως*,[2] reveals the cosmic force and unity to the millions of men, will ever hold its own against a merely destructive Buddhism, whether ancient or modern; and, long after pure Logic has said its last word and—with a faint cry, "Something perhaps is"—has evaporated into Nirwana, will continue its thrice-blessed efforts to rear a palace of human thought, will handle with reserve and dignity the best results of all the sciences, and will integrate (with courage and not despair) the infinite contributions of all phenomena into a theology of practical utility to the further evolution of the human race.

For evolution there has certainly been. And in spite of all that has been said to the contrary,[3] the moral atmosphere which has from age to age rendered mental progress possible has been, for the most part, engendered by religion, and, above all, by the confidence, peace, and brotherhood preached by the Christian Church. No doubt religion was cradled amid gross superstitions; and only by great and perilous transitions has it advanced from the lower to the higher. It was a great step from the fetich and the teraphim to the animal and plant

[1] 2 Timothy i. 7.

[2] At sundry times and in divers manners.

[3] Draper, "The Conflict between Religion and Science," New York, 1873. This otherwise admirable work is disfigured throughout by a prejudice against religion, as a factor in human progress, which is almost childish. The learned author surely forgets his own words, "No one can spend a large part of his life in teaching science, without partaking of that love of impartiality and truth which philosophy incites" (p. ix.).

symbols of Egypt and Assyria. It was another great step to Baal, the blazing sun, and Moloch, wielder of draught and sunstroke, and Agni, friendly comrade of the hearth. But when astronomy and physics had reached sufficient growth to master all these wonders, and to predict the solstices and the eclipses, then the fullness of times had come once more; and now the greatest religious transition was accomplished that the human race has ever seen—a transition from the physical, and the brutal, and the astral, to the human and the moral, in man's search after a true (or the to him truest possible) representation of the infinite forces at play around him. In Abraham the Hebrew—עברי, the man who made the great transition—this important advance is typified for the Semitic races; for others, the results only are seen in the Olympian conceptions of Hesiod and Homer. For here we have, at last, the nature-forces presided over and controlled after a really human fashion. Crude, and only semi-moral, after all, as was this earliest humanizing effort, still human it was—not mechanical nor bestial. And it opened the way for Socrates to bring down philosophy, too, from heaven to earth, for Plato to discuss the mental processes in man, and apply them (writ large) to the processes of nature, and for Moses to elaborate with a divine sagacity a completely organized society, saturated through every fiber with this one idea—the unity of all the nature-forces, great and small, and their government, not by hap-hazard, or malignity, or fate, but by what we men call LAW. "Thou hast given them a law which shall not be broken." For this word "law" distinctly connotes rationality. It implies a quality akin to, and therefore expressible in terms of, human reason. Its usage on every page of every book of science means that; and repudiates, therefore, by anticipation, the dismal invitations to scientific despair with which the logicians *à outrance* are now so pressingly obliging us.

This grand transition, then, once made, all else became easy. The human imagination, the poetic or plastic power lodged in our brain, after many failures, had now at last got on the high-road which led straight to the goal. Redemption had come; it only needed to be unfolded to its utmost capabilities. Dull fate, dumb, sullen, and impracticable, had been renounced as infra-human and unworthy. Let stocks and stones in the mountains and the forests be ruled by it; not free, glad, and glorious men! Brute, bestial instinct also had been renounced, as contemptible and undivine in the highest degree. And so, at last, the culminating point was attained. The human-divine of Asiatic speculation, and the divinely-human of European philosophy, met and coalesced; and from that wedlock emerged Christianity. The "Something is" of mere bald analytic reasoning had become clothed by the imagination with that perfect human form and character than which nothing known to man is higher; and that very manhood, which is nowadays so loudly asserted by positivists and atheists to be the most divine thing known to science, was precisely the form in which

the new religion preached that the great exterior existence, the Something Is, the awful "I AM," can alone be presented intelligibly to man. For "No man shall see Jehovah and live," says the Old Testament: "No man hath seen God at any time," says the New Testament; the Son of man, who is *εἰς τὸν κόλπον τοῦ πατρὸς*[1]—projected on the bosom of the absolute "I am"—he hath declared him.

Of this language in St. John's Gospel, it is obvious that Hegel's doctrine—echoed afterward by Comte and the positivists—is a sort of variation set in a lower key. In humanity, said he, the divine idea emerges from the material and the bestial into the self-conscious. Humanity presents us with the best we can ever know of the divine. In "the Son of man" that SOMETHING which lies behind, and which no man can attain to, becomes incarnate, visible, imaginable. But it can not surely be meant by these philosophers that in the sons of men *taken at hap-hazard* the Divinity, the great Cosmic Unknown, is best presented to us. It can not possibly be maintained that in the Chinese swarming on their canals, in the hideous savages of Polynesia, or in the mobs of our great European capitals, the "Something is" can be effectively studied, idealized, adored. No, it were surely a truer statement that humanity concentrated in its very purest known form, and refined as much as may be from all its animalism, were the clear lens (as it were) through which to contemplate the great Cosmic Power beyond. It is, therefore, a SON of man, and not the ordinary sons of men, that we require to aid our minds and uplift our aspirations. Mankind is hardly to be saved from retrograde evolution by superciliously looking round upon a myriad of mediocre realities. It must be helped on, if at all, by a new variety in our species suddenly putting forth in our midst, attracting wide attention, securing descendants, and offering an ideal, a goal in advance, toward which effort and conflict shall tend. We must be won over from our worldly lusts and our animal propensities by engaging our *hearts* on higher objects. We must learn a lesson in practical morals from the youth who is redeemed from rude boyhood and coarse selfishness by love. We must allow the latent spark of moral desire to be fanned into a flame, and, by the enkindling admiration of a human beauty above the plane of character hitherto attained by man, to consume away the animal dross and prepare for new environments that may be in store for us. What student does not know how the heat of love for truth not yet attained breaks up a heap of prejudices and fixed ideas, and gives a sort of molecular instability to the mind, preparing it for the most surprising transformations? Who has not observed the development of almost a new eye for color, or a new ear for refinements in sound, by the mere constant presentation of a higher æsthetic ideal? And just in the same way, who that knows anything of mankind can have failed to perceive that the only successful method by which character is permanently improved is by employ-

[1] On the Father's bosom.

ing the force of example, by accumulating on the conscience reiterated touches of a new moral color, and by bringing to bear from *above* the power of an acknowledged ideal, and (if possible) from *around* the simultaneous influence of a similarly affected environment?

Baptize now all these truths, translate them into the ordinary current language of the Church, and you have simply neither more nor less than the gospel of Jesus Christ. And as carbon is carbon, whether it be presented as coal or as diamond, so are these high and man-redeeming verities—about the inscrutable "I am," and his intelligible presentment in a strangely unique SON OF MAN, and the transmuting agency of a brotherhood saturated with his Spirit and pledged to keep his presence ever fresh and effective—verities still, whether they take on homely and practical or dazzling and scientific forms. And the foolish man is surely he who, educated enough to know better, scorns the lowly form, and is pedantic enough to suggest the refinements of the lecture-room as suitable for the rough uses of every-day life. A man of sense will rather say: Let us by all means retain and—with insight and trust—employ the homely traditional forms of these sublime truths: let us forbear, in charity for others, to weaken their influence, and so to cut away the lower rounds of the very ladder by which we ourselves ascended: and let us too, in mercy to our own health of character, decline to stand aloof from the world of common men, or to relegate away among the lumber of our lives the ἔπεα φωνᾶντα συνέτοισιν[1] that we learned of simple saintly lips in childhood. Rather, as the SON OF MAN hath bidden us, we will "bring out of our treasures things both new and old"; will remember, as Aquinas taught, that "nova nomina antiquam fidem de Deo significant"[2]; and will carry out in practice that word well spoken in good season, "It is not by rejecting what is formal, but by interpreting it, that we advance in true spirituality."[3]

II. On the other hand, if men of science are to be won back to the Church, and the widening gulf is to be bridged over which threatens nowadays the destruction of all that we hold dear, it can not be too often or too earnestly repeated, *The Church must not part company with the world she is commissioned to evangelize.* She must awake both from her renaissance and her mediæval dreams. To turn over on her uneasy couch, and try by conscious effort to dream those dreams again, when daylight is come and all the house is fully astir, this surely were the height of faithless folly. An animating time of action is come, a day requiring the best exercise of skill and knowledge and moral courage. Shall we hear within the camp, at such a moment as this, a treasonable whisper go round: "By one act of mental suicide we may contrive to escape all further exertion; science is perplexing, history is full of doubts, psychology spins webs too fine for our self-indulgence

[1] Words that have a meaning for those who understand.

[2] The new terms signify the ancient faith concerning God.

[3] "The Patience of Hope," p. 70.

even to think of? Why not make believe very hard to have found an infallible oracle, and determine once for all to desert our post and 'jurare in verba magistri'[1]?" It is true that history demonstrates beyond a doubt that Jesus and his apostles knew nothing of any such contrivance. But never mind! "A Catholic who should adhere to the testimony of history, when it appears to contradict the Church, would be guilty not merely of treason and heresy, but of apostasy."[2] Yes, of treason to Rome, but of faithful and courageous loyalty to Christ. "I am the truth," said Christ. "The truth shall make you free." Speak the truth in love, prove all things, hold fast that which is true, said his apostles. How can it ever be consonant to his will that the members of his brotherhood should conspire together to make believe that white is black at the bidding of any man on earth? The Church of England, at any rate, has no such treason to answer for. Her doctrinal canons, by distinctly asserting that even "General Councils may err and have erred," and by a constant appeal to ancient documents, universally accepted, but capable of ever-improving interpretation, have averted the curse of a sterile traditionalism. No new light is at any time inaccessible to her. Every historical truth is treasured, every literary discussion is welcome, every scientific discovery finds at last a place amid her system. Time and patience are, of course, required to rearrange and harmonize all things together new and old; and a claim is rightly made that new "truths" should first be substantiated as such, before they are incorporated into so vast and widespread an engine of popular education as hers. But, with this proviso, "Theology accepts every certain conclusion of physical science as man's unfolding of God's book of nature."[3] It is therefore most unwise, if any of her clergy pose themselves as hostile to new discoveries, whether in history, literature, or science. It may be natural to take up such an attitude; and a certain impatience and resentment at the *manner* in which these things are often paraded, in the crudest forms and before an unprepared public, may be easily condoned by all candid men. But such an attitude of suspicion and hostility between "things old" and "things new" goes far beyond the commission to "banish and drive away all strange and erroneous doctrines contrary to God's word." For this commission requires proof, and not surmise, that they are erroneous; and the Church has had experience, over and over again, how easy and how disastrous it is to banish from the door an unwelcome guest, who was perhaps nothing less than an angel in disguise. The story of Galileo will never cease, while the world lasts, to cause the enemies of the Church to blaspheme. Yet of late years it has been honestly confessed by divines that "the oldest and the youngest of the natural sciences, astronomy and geology, so far from being dangerous, . . . seem providentially destined to engage

[1] Swear as a master bids.

[2] Abbé Martin, "Contemporary Review," December, 1878, p. 94.

[3] Dr. Pusey, "University Sermon," November, 1878.

the present century so powerfully that the ideal majesty of infinite time and endless space might counteract a low and narrow materialism."[1]

This experience ought not to be thrown away. No one, who has paid a serious attention to the progress of the modern sciences, can entertain a doubt that all the really substantiated discoveries which have been supposed to contravene Christianity do in reality only deepen its profundity and emphasize its indispensable necessity for man. Never before, in all the history of mankind, has the Deity seemed so awful, so remote from man, so mighty in the tremendous forces that he wields, so majestic in the permanence and tranquillity of his resistless will. Never before has man realized his own excessive smallness and impotence; his inability to destroy—much more, to create—one atom or molecule; his dependence for life, for thought, for character even, on the material environment of which he once thought himself the master. The forces of nature, then, have become to him once more, as in the infancy of his race, almost a terror. And poised midway, for a few eventful hours, between an infinite past of which he knows a little and an infinite future of which he knows nothing, he is tempted to despair of himself and of his little planet, and in childish petulance to complain, "My whilom conceit is broken; there is nothing else to live for." And amid these foolish despairs, a voice is heard which says: "Have faith in God! have hope in Christ! have love to man! Knowledge of this tremendous substratum of all being it is not for man to have: his knowledge is confined to phenomena and to very human (but sufficient) conceptions of the so-called laws by which they all cohere. But these three qualities are moral, not intellectual, virtues. For the Church never teaches that God can be scientifically known; she never offers certainty and sight, but only "hope," in many an ascending degree; she does not say that God is a man, a person like one of us—that were indeed perversely to misunderstand her subtile terminology—but only a MAN has appeared, when the time was ripe for him, in whom that awful and tremendous existence has shown us something of his ideas, has made intelligible to us (as it were by a word to the listening ear) what we may venture to call his "mind" toward us, and has invited us—by the simple expedient of giving our heart's loyalty to this most lovable Son of man—to reach out peacefully to higher evolutions, and to commit that indestructible force, our life, to him in serene well-doing to the brotherhood among whom his Spirit works, and whose welfare he accounts his own.

Is not this *humanizing* of the great Existence, for moral and practical utility, and this *utterance* (so to speak) of yet another creative word in the ascending scale of continuous development, and this *socializing* of his sweet, beneficent Spirit in a brotherhood as wide as the world, precisely the religion most adapted to accord with modern science?

[1] Kalisch, "On Genesis," p. 43.

Yet no one can listen to ordinary sermons, no one can open popular books of piety or of doctrine, without feeling the urgent need there is among Churchmen for a higher appreciation of the majestic infinitude of God. It is true that, in these cases, it is the multitude and not the highly educated few who are addressed; and that, even among that multitude, there are none so grossly ignorant as to compare the Trinity to "three Lord Shaftesburys," and not many so childish as to picture "one Almighty descending into hell to pacify another."[1] Such petulance is reserved for men of the highest intellectual gifts, who—whether purposely or ignorantly, it is hard to say—have stooped to provide their generation with a comic theology of the Christian Church. But, after all, it is impossible not to feel that the shadows of a well-loved past are lingering too long over a present that might be bright with joyous sunshine; that the subtilties of the schoolmen are too long allowed to darken the air with pointless and antiquated weapons; that the Renaissance, with its literary fanaticism, still reigns over the whole domain of Christian book-lore; and that the crude conceptions of the Ptolemaic astronomy have never yet, among ecclesiastics, been thoroughly dislodged or replaced by the far more magnificent revelations of the modern telescope. It is not asserted that no percolation of "things new" is going on. It is not denied that as in the first century a change in ideas about the priesthood carried with it a change in the whole religious system of which that formed the axis,[2] so now a change in ideas about the earth's position in space demands a very skillful and patient readjustment of all our connected ideas. But such a readjustment of the old Semitic faith was effected, in the first century, by St. Paul; and there is no reason to think that the Church is unequal to similar tasks now. And in this country especially there is an established and organized "Ecclesia docens"[3] which probably never had its equal in all Church history for the literary and scientific eminence of its leading members. For such a society to despair of readjusting its theology to contemporary science, or idly to stand by while others effect the junction, were indeed a disgraceful and incredible treason; so incredible that—until it be proved otherwise—no amount of vituperation or unpopularity should induce any reflecting Englishman to render that work impossible by allowing his Church to be trampled down, and its time-honored framework to be given up as a spoil to chaos.

But there is yet another element in this question which binds the Church of Christ to give to its solution the very closest and most indefatigable attention. It is this: that from every science there arises nowadays a cry like that addressed to Jesus himself when on earth, "Lord, help me!" It is not as if atheism were satisfied with itself. In the pages of the "National Reformer" and similar organs of aggres-

[1] M. Arnold, "Literature," etc. (1873), p. 306. Spencer, "Sociology" (seventh edition, 1878), p. 208.

[2] Hebrews vii. 12.

[3] Teaching Church.

sive free thought we are amused with the buoyant audacity of the "young idea." Yet even there we find many a passage which calls forth the sincerest sympathy. Take, for instance, the following:

> There are few reflective persons who have not been, now and again, impressed with awe as they looked back on the past of humanity. . . . It is then that we see the grandest illustrations of that unending necessity under which, it would seem, man labors, the necessity of abandoning ever and again the heritage of his fathers, . . . of continually leaving behind him the citadel of faith and peace, raised by the piety of the past, for an atmosphere of tumult and denial. . . . Whatever may be our present conclusions about Christianity, we can not too often remember that it has been one of the most important factors in the life of mankind."[1]

This is touching enough—though perhaps the stolid aggressiveness which knows, as yet, no relentings, is really a far more tragic spectacle. But there are other lamentations, uttered of late years by distinguished atheists, which might move a heart of stone, much more should stir the energies of every Christian teacher—himself at peace—to seek by any sacrifice of his own ease or settled preconceptions an "eirenicon," a method of conciliation, an opening for a mutual confession of needless estrangement and provocation.

> Does that new philosophy of history which destroys the Christian philosophy of it afford an adequate basis for such a reconstruction of the ideal as is required? Candidly we must reply, "Not yet." . . . Very far are we from being the first who have experienced the agony of discovered delusion. . . . Well may despair almost seize on one who has been, not in name only, but in very truth, a Christian, when that incarnation which had given him in Christ an ever-living brother and friend is found to be but an old myth [of Osiris] with a new life in it.[2]
>
> The most serious trial through which society can pass is encountered in the exuviation of its religious restraints.[3]
>
> Never in the history of man has so terrific a calamity befallen the race as that which all who look may now behold advancing as a deluge, black with destruction, resistless in might, uprooting our most cherished hopes, ingulfing our most precious creed, and burying our highest life in mindless desolation. The flood-gates of infidelity are open, and atheism overwhelming is upon us. . . . Man has become, in a new sense, the measure of the universe; and in this, the latest and most appalling of his soundings, indications are returned from the infinite voids of space and time that his intelligence, with all its noble capacities for love and adoration, is yet alone—destitute of kith or kin in all this universe of being. . . . Forasmuch as I am far from being able to agree with those who affirm that the twilight doctrine of the "new faith" is a desirable substitute for the waning splendor of "the old," I am not ashamed to confess that, with this virtual negation of God, the universe to me has lost its soul of loveliness. And when at times I think, as think at times I must, of the appalling contrast between the hallowed glory of that creed which once was mine and the lonely

[1] Bradlaugh's "National Reformer," October 6, 1878.

[2] Stuart Glennie, "In the Morning Land" (1873), pp. 29, 378, 431.

[3] Draper, "Religion and Science" (eleventh edition, 1878), p. 328.

mystery of existence as now I find it—at such times I shall ever feel it impossible to avoid the sharpest pang of which my nature is susceptible.[1]

It is well that Churchmen should be aware of this state of things; and especially that the clergy, when they are tempted to have their fling (secure from all reply) against the so-called "infidel," should bear in mind how often the bravery of defiant arrogance is a mere mask to cover a sinking heart. For pity's sake, therefore, as well as for their own sake, the clergy should guard against two gross but common mistakes: 1. The mistake of abusing modern science, and depreciating its unquestionable difficulties in relation to the established theology; 2. The still more fatal blunder of trusting to worn-out tactics and to the "artillery" of Jonathan and David for the reduction of these modern earthworks. "To the Greeks became I as a Greek," said St. Paul. And so must the minister of Christ in these days make up his mind to bring home the gospel to his own countrymen, with all their faults and peculiarities; and to the Englishmen of the nineteenth century must become an Englishman of the nineteenth century, that he "may by all means save some."

But no success will be obtained, unless Churchmen will remember that the vast domains recently conquered by science are (practically speaking) assured and certain conquests. They are no encroachment, but a rightful "revindication" of scientific territory. And, accepted in a friendly spirit, harmonized with skill and boldness, and consecrated (not cursed) in the Master's name, they bid fair to become a new realm whereon his peace-bringing banner may be right royally unfolded, and where, even in our own day, the beginning of a permanent unity may certainly be effected. And this must be attempted by a brave and telling proclamation of the great Christian doctrines—that the awful self-existent "I AM" is none other than "our Father in heaven"; that Christ, the blameless Son of man, is the best image of his person; and that his pure Spirit, brooding over the turbid chaos of human society, offers the surest means and pledge of a future Cosmos, where "life" may perhaps transcend these baffling veils of space and time, and, in forms "undreamed of by our philosophy," display the boundless riches of nature and of God.—*Contemporary Review.*

THE STING OF THE HONEY-BEE.[2]

PERHAPS there is no object more common in the cabinets of microscopists than mounted specimens of bee-stings. Almost every popular work on the microscope describes and figures them, but it is

[1] Physicus, "On Theism," pp. 51, 63, 114.

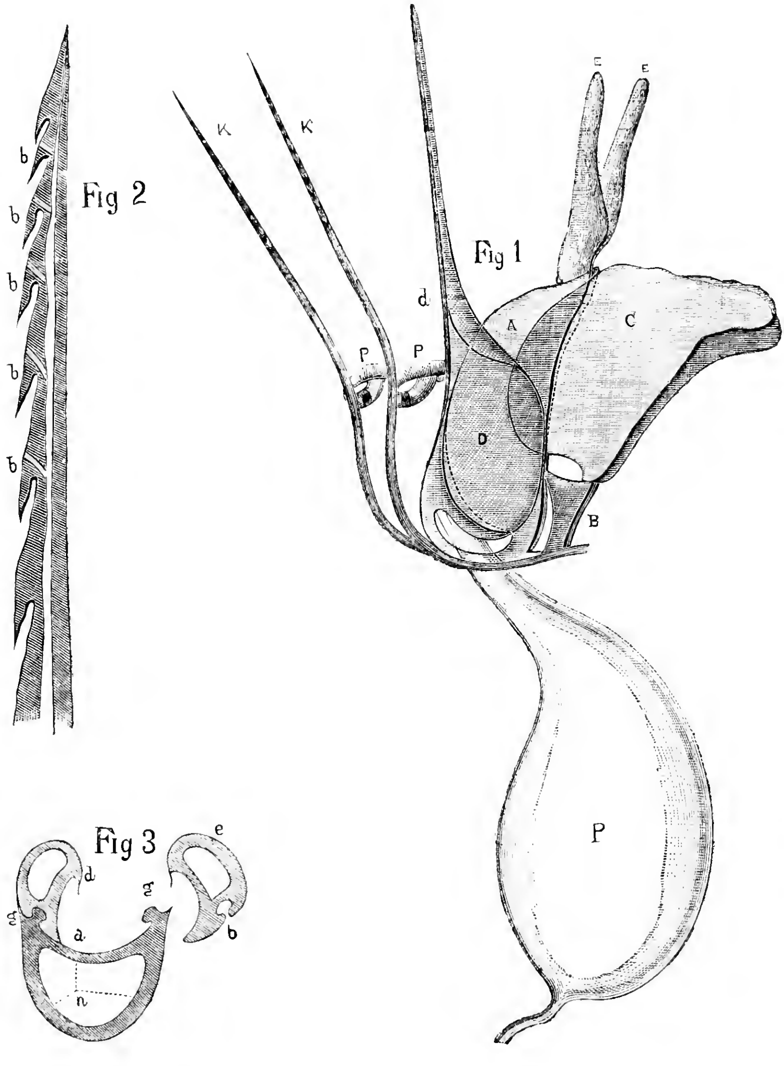
[2] Abstract from a paper, by J. D. Hyatt, in the "American Quarterly Microscopical Journal," October, 1878.

only within a few months that the true structure of these organs has been made known. Mr. J. D. Hyatt, of this city, has been studying the subject for the past eight years, and his recent discoveries have shown that the ordinary descriptions are incorrect and founded upon mere inferences, drawn from the appearance of the organ as usually dissected and mounted. There are no less than eight discoveries, for which we are indebted to the labors of this gentleman, and it is our intention to present some of these as briefly as possible.

By reference to the cuts the following descriptions will be made clear: Fig. 1 represents the entire apparatus of the sting of the honey-bee, with the muscles removed, showing only the hard parts and the poison-gland (*P*). The lancets (*K K*) are drawn out from their natural position to show their structure more clearly. The sting is usually described as having two barbed lancets (*K K*) which move in and out of the "sheath" (*D*), the inner sides of the lancets being channeled, so that when they are thrust out together they form a tube through which the poison enters the wound. It appears, however, that the so-called "sheath" does not inclose the lancets in any part, and therefore is not a sheath, as formerly supposed. Moreover, while the virus may, and undoubtedly does, pass along the tubular space between the lancets, this is not the course it follows to reach the bottom of the wound. A far more elaborate arrangement, a sort of miniature hydraulic ram, forces the fluid through the lancets themselves, and this is one of the most recent discoveries. By examining the lancets with a rather high power, it will be seen that each appears to be tubular, and that the tube runs down nearly to the apex, but always disappears before reaching the end. From this main tube, and just back of each of the last five teeth, we notice fine branch-tubes which open on the surface between them. All this is well shown in Fig. 2, the branch-tubes opening at the points *b b b b b*. This figure represents the lower part of one of the lancets, showing the shape of the barbs and the extremely sharp point. The lancet is thus seen with a power of four hundred and fifty diameters; the point of the finest sewing-needle magnified to the same extent would appear as blunt as the end of a crowbar. Although the tubular appearance was evident to any one who looked for it, the next step was to prove that the lancets were in truth hollow, for it is not safe to rely upon mere appearances when using the microscope. Mr. Hyatt succeeded in proving their tubular nature in several ways: he succeeded in forcing liquid through them, first by a little delicate manipulation, and finally by cutting thin transverse sections and mounting them so as to view them on end. One of these sections, which shows the form of the lancet and the tubular opening passing through it, is shown at *e*, Fig. 3.

Following the lancet from the apex toward the larger end we pass the gracefully curved barbs to a smooth portion, and then reach a curious projection (Fig. 1, *p*), firmly braced and attached to the lancet as

seen in the figure. When in the natural position these projections lie within the "sheath" (*D*). These are known as the stop-valves. The tubes of the lancets terminate just back of where the stop-valves are attached, here opening into the cylindrical portion of the "sheath."



We pass now from the lancets to the "sheath" (Fig. 1, *D*). The general shape is well shown in the figure. The cylindrical portion (*D*) suddenly contracts, forming a shoulder at *d*, and a slender portion extends for some distance beyond. Along the straight edge the lancets

run in the manner shown in Fig. 3. In this figure the darker portion (*n*) represents a cross-section of the "sheath," the two lighter pieces (*b* and *d*) are cross-sections of the lancets, one (*d*) *in situ*. Running the entire length of the "sheath" we find the T-rail projections (*g g*) along which the lancets slide, being channeled to fit, as seen at *b*, Fig. 3. Thus we see that the main "sheath" is not a proper term for this part of the apparatus, for the lancets are entirely outside of it and run along the rails. The poison-gland (*P*) empties into the cylindrical part of the sheath, and keeps it constantly full of virus, at least when the bee is excited. *A*, *B*, and *C*, are broad chitinous pieces, to which muscles are attached. They form a peculiar combination of levers, too complicated in their action to be described here in detail, but they serve to thrust out the "sheath" and the lancets, giving to the former a powerful thrust, and to the latter a movement of great rapidity.

We are now prepared to understand the operation of stinging. The two lancets (*K K*) when in position lie close against the "sheath," as already described, and their ends reach just to the point of the latter. When the insect stings, the palpi (*E E*), which are drawn away from their proper place in the figure, serve to direct the organ to the most vulnerable point of attack. Then, with a sudden, powerful motion, the "sheath" is forced out and produces the puncture, penetrating as far as the point *d*, where the expansion begins. Instantly the two lancets are then forced out together, increasing the depth of the wound made by the "sheath." It has generally been supposed that the lancets were the organs that made the puncture, but this is not the fact. The lancets are thrust out until the stop-valves (*p p*) strike against the shoulder *d* (Fig. 1). This closes the cylindrical part of the sheath, which is full of virus, and this virus, being under pressure either from the sudden stoppage of the free outlet by the stop-valves or the contractions of the poison-gland (*P*), or both these causes combined, makes its way into the tubular lancets through the openings already mentioned just back of the stop-valves, and enters the wound through the branch-tubes *b b b b b* (Fig. 2). Thus we see that the injection of the poison into the wound is fairly comparable to the working of an hydraulic ram.

When the honey-bee stings, it is well known that the sting is not withdrawn from the wound. The sharp barbs on the lancets make it impossible for the bee to withdraw them, but more than these may be left behind. By allowing the insect to sting a piece of soft leather, not only the lancets but also the sheath and poison-gland will be beautifully dissected out, the bee apparently not suffering from their loss.

It will be seen that the lancets are curved at their attachment with the levers which move them. This curved portion is flexible, while the points are brittle. The poison-gland is provided with a muscular coat. It has been previously supposed that the virus was expelled from the gland by the pressure of other parts. There are several interesting points connected with the mechanism of the sting, which have been

omitted here on account of the detailed description that would be required to make them intelligible.

Naturalists should not be slow to appreciate the conscientious labor which alone has led Mr. Hyatt to these results, or to follow up the line of investigation which he has opened.

REFLEX ACTION AND DISEASE.

By T. LAUDER BRUNTON, F.R.S.

As a preliminary to the paper of this evening upon reflex action as a cause of disease and a method of cure, I must say a word about reflex action itself, and also about another subject with which it is very closely connected, viz., the transference of impressions.

Reflex action is the effect produced by an impression made upon a sensory nerve, transmitted by that nerve to a nerve-center, and reflected or thrown back along a motor nerve in much the same way as we may imagine the force to be which is applied to one end of a string running over a pulley and transmitted in a different direction by the other end to produce a certain effect. If we fancy the farther end of the string to be divided into several strands, each of which is attached to a different object, and which may be, separately or together, affected by a pull on the nearer end of the string, we shall form a still more definite notion of reflex action, for an impression made upon the same sensory nerve may produce various results, according to the strength of the impression and the efferent nerve-channel along which it is thrown back by the nerve-center. An impression made upon a sensory nerve, for example, may produce motion of either a voluntary or involuntary muscle, or may affect the nutrition of a tissue. Under the head of involuntary muscles we must class the muscular fibers of the vessels, and those vascular changes which in themselves play a great part in nutrition and secretion may be very greatly influenced by impressions made upon sensory nerves. The way in which we know that the nutrition of a tissue may be influenced reflexly apart from the changes in the vessels is, that observations on the submaxillary gland have demonstrated that we may, under certain conditions, obtain vascular changes without the secretion which usually accompanies them, and that, *vice versa*, we may obtain secretion without the vascular changes which ordinarily accompany it. Thus, on stimulating the nerves of the tongue, the impression which we make is usually transmitted by the fifth nerve to the brain, and is thence reflected down the chorda tympani to the submaxillary gland. There it induces dilatation of the vessels, and free secretion of saliva from the gland. But if we administer atropia we do away with one of these

[1] Read before the Abernethian Society, St. Bartholomew's Hospital.

results, while we leave the other as it was—we completely arrest the secretion, but we allow the vessels to dilate as before. If, on the other hand, we employ physostigma, we contract the vessels, but cause great secretion, such secretion as is usually accompanied by dilated vessels and the free flow of blood through the gland. It is evident, then, that vascular changes, although usually associated with alterations in nutrition, do not necessarily cause them; and that, in the gland we have just mentioned, changes in the tissues composing it will occur without the caliber of the vessels or the flow of blood through them undergoing any material alteration.

We will now say a word about the transference of impressions. Just as we may imagine the farther side of the cord passed over the pulley to be divided into different strands, while the nearer side is single, and as we imagine different results obtained by pulling upon the single string by reason of those subdivisions at its farther end, so we may have the nearer end of the cord subdivided into strands, while the farther end is single, and thus we can obtain a similar result by pulling any one of the strands on the nearer end. This simile may serve to illustrate the way in which we may obtain a similar result by irritation of various efferent nerves, the stimulation being conveyed to the nerve-center and reflected down the same efferent nerve in each case. For example, a small grain of sand in the eye will cause a person to wink violently and involuntarily. In this case the impression made upon the sensory nerves of the conjunctiva is transmitted up to the brain, and reflected down the motor nerves of the orbicularis palpebrarum. But some time ago, after the extraction of a tooth, and while the wound in the gum was healing, I observed a twitching in the corresponding eyelid somewhat resembling that which would have been caused by a grain of sand in the eye. Here, also, we have the motor nerves of the orbicularis reflexly excited, but the strand, if we may so term it, through which the stimulus was sent up the nerve-center was not the same, for in this case it was a dental and in the other case an ophthalmic branch of the fifth. With these general remarks on reflex action and transference of impressions, we will now proceed to consider some cases in which reflex action is a cause of disease. I have just mentioned one instance in which intermittent spasm of a voluntary muscle, the orbicularis palpebrarum, was caused by irritation of a sensory nerve. This leads me to remark that a very important condition to be borne in mind is that constant stimulation of a sensory nerve will often produce clonic or intermittent, and not tonic or continuous, contraction of the muscles which it may set in action. It was observed by Nothnagel that if the sciatic nerve of a frog's leg was subjected to constant stimulation under certain conditions, the contractions which it induced reflexly in the other leg were intermittent or spasmodic, but not continuous or tetanic. Another instance in which voluntary muscles are reflexly affected is seen in the acts of coughing and vomiting.

Coughing is adapted for the purpose of expelling irritating substances from the respiratory passages, and thus preventing their injuring the organism, just as the act of winking is adapted to remove injurious substances from the eye. Coughing is usually excited by irritation of the nerves of that part of the body from which the irritant is to be removed. But coughing, like winking, may be reflexly induced by other nerves than those which usually excite it, and thus may prove hurtful instead of useful. Thus, in pleurisy, irritation of the pleura causes the same expulsive efforts as a foreign substance in the bronchi, although those efforts can expel nothing, and only cause pain to the patient; and even when the act of coughing is induced from the ordinary nervous channels, but where the irritant, like tubercle in the lungs, can not be removed, the act is likewise injurious. In the same way, vomiting is most frequently induced by the presence of irritating substances in the stomach, and proves useful by causing their rejection and thus relieving the stomach of their obnoxious presence. But when the irritation is due to inflammation of the walls of the stomach itself, the expulsive efforts of retching are quite useless, and only exhaust the patient. Here, too, the act of vomiting can be induced by irritation of other nerves than those of the stomach itself. Irritation of the pharyngeal branches of the glosso-pharyngeal and of the pulmonary branches of the vagus, irritation of the hepatic nerves by the passage of a biliary calculus, irritation of the renal nerves by a calculus resting in the kidney or passing down the urethra, irritation of the intestinal nerves (as, for instance, by incarceration of a hernia), irritation of the uterine nerves by the presence of a fœtus in the womb, or of the ovarian and vesical nerves by inflammation of the ovaries or bladder, may all produce vomiting; and in all, or nearly all, these cases, efforts at emesis will be productive of no beneficial result. When the irritation is further down the intestine, as when an ulcer is situated in the rectum, there is a constant desire to go to stool, but the only results of the expulsive efforts involved in its gratification are exhaustion of the patient and aggravation of the ulcerated condition. In the efforts of micturition, as in those of vomiting and defecation, we have combined movements of voluntary and involuntary muscles. The urine is retained in the bladder by the contraction of the sphincter surrounding its neck, and it is expelled by contraction of the body of the bladder itself with the assistance of the abdominal muscles. Both the sphincter of the neck of the bladder and the muscular walls of the organ itself may be reflexly excited to contraction, and we may thus have reflex incontinence or reflex retention. One of the most common causes of incontinence of urine, for example, is the presence of ascarides in the rectum; and while the ascarides remain we may employ drugs to cure the incontinence without success. An interesting case is described by Mr. Teevan in the "Practitioner" for October, 1876, where a boy had been treated in vain by medicine, but was at once cured by healing a fistula

in ano from which he had been suffering, the irritation produced by it appearing to have been the real cause of the incontinence.

We will now pass from reflex changes in the respiratory and intestinal tracts to reflex changes in the blood-vessels and heart. It is well known that, usually, irritation of a sensory nerve causes dilatation of the vessels in the part supplied by that nerve, and contraction of the vessels in the other parts of the body. This may take place without any alteration whatever in the beats of the heart itself; but if the irritation be very strong, or applied to certain nerves, the heart also may be acted upon. There seem to be certain nerves which act more readily upon the heart than others, and more especially is this power possessed by the fifth nerve, the roots of which are very closely associated with those of the vagus. On stimulation of the branches of the fifth nerve passing to the nose in animals—as, for example, by holding ammonia, strong acetic acid, or chloroform before the nose of a rabbit—the beats of the heart may be suddenly and completely arrested. To a similar arrest of the cardiac pulsations by irritation of the dental branches of the fifth, I attribute the numerous deaths which have occurred through the extraction of teeth under chloroform. It is probable that the extraction of teeth would, under all circumstances, be an exceedingly dangerous operation, were it not that in the waking condition irritation of the dental nerves sets in motion two pieces of mechanism, one of which, to a great extent, counteracts the effects of the other. As I have already mentioned in a former paper, I was once asked how it was that the application of ammonia or acetic acid to the nose of a fainting person was proved by experience to be beneficial, when theoretically it ought to be injurious by arresting the already enfeebled heart. The answer to this is, that ammonia or acetic acid, held before the nose of a fainting person, by irritating the branches of the fifth nerve, does not act upon the heart alone—it causes contraction of all the vessels of the body, and thus keeps the arterial system full, and the blood-pressure high, despite the diminished current poured into it by the flagging heart. So much is this the case, that I have found, in an animal in which the heart was weakened and the vessels dilated by shock, that the application of ammonia or acetic acid to the nose raised the pressure by one fourth of the whole. In the ordinary waking condition, the sudden stimulus of extracting the tooth has its effect upon the heart completely counteracted by the coincident contraction of the arterioles throughout the body which it also causes. In chloroform narcosis, however, these two reflexes are not influenced equally by the drug, and the reflex upon the heart may remain after the reflex action upon the vessels has been abolished, so that the heart may stop, and death will then ensue; for, the capillaries being no longer contracted, the blood at once drains out of the arteries into the veins, and circulation ceases. Another very important reflex upon the heart is that which is effected through the solar plexus and the sym-

pathetic nerve. A stroke upon the belly will through these nerves stop the heart, dilate the vessels, and induce the most serious conditions of shock, killing the patient, or at any rate bringing him down to death's door. The most important nerves through which the vessels are reflexly contracted are the splanchnics, and the contraction of the abdominal vessels which they supply has much more effect in altering the general pressure of blood throughout the arterial system than the contraction of any other vascular district in the body. But although the abdominal vessels are the chief ones concerned in alterations of blood-pressure, yet local alterations in the various organs may have an even more powerful action upon the nutrition of these organs themselves; for it is probable that although the abdominal vessels may be caused to contract by powerful stimulation of almost any sensory nerve, yet that the blood-vessels in different organs of the body—such as, for example, the kidneys or mucous membranes—are more affected by irritation of some nerves than of others. The researches of Sanders-Ezn have shown that stimulation of certain sensory nerves, or of limited districts of the skin, will induce definite muscular action due to contraction of limited groups of muscles. It is probable that irritation of limited districts of the skin also induces contraction of limited groups of involuntary muscular fibers or of limited districts of vessels. It is well known that tonsillitis is much more frequently produced by exposure to a draught which strikes the back or side of the head than by a current of air meeting one full in the face, or even by long-continued exposure to a storm in the open air. The cause of this has not yet been satisfactorily ascertained, but it has been attributed with some probability to irritation of the nerves of the ear by the cold current of air. When the throat is irritated, the irritation is not unfrequently felt in the ear; and, *vice versa*, it seems probable that irritation in the ear may cause alterations in the throat. It has been observed that pressure upon the floor of the external auditory meatus in a person who had suffered from otorrhœa produced violent or uncontrollable coughing; and, if irritation of the ear thus produces a motor reflex like that of irritation of the larynx, it seems probable that it may also produce a reflex trophic disturbance similar to that which would have followed the direct application of an irritant to the larynx.

Congestion of the kidneys in horses is caused by exposure of the loins to rain, the action of cold upon that district of the general surface having a peculiar effect upon the kidneys, not produced by its application to other parts of the body. It is stated by Sidney Ringer, upon Brown-Séquard's authority, that blistering the loins will cause contraction of the vessels of the kidney, but I have not been able to verify this quotation. But, though there seems to be a peculiar relation between the loins and the kidney, the renal circulation would appear to be affected by other nerves. Thus, for example, in a case narrated by Dr. Griffith at a meeting of the Medical Society of London, albu-

minuria was produced by the application of a dressing to an anal fistula, which ceased when the dressing was removed, and again appeared on its reapplication. In this case the vessels of the kidney seem to have been reflexly affected by the irritation applied to the anal nerves to such an extent as to produce albuminuria, although probably no organic disease of the kidneys themselves was present. Exposure of the abdominal walls to rapid changes in temperature may bring on diarrhœa, as the natives of India well know. It is possible that in these instances the cold acts through the abdominal walls upon the intestines themselves; but it seems also highly probable that some part at least of the action is reflex from the surface of the abdomen. Whatever the cause of it may be, however, it may be guarded against by wearing a *cummerbund*, like the Hindoos; and it is well for persons who are subject to diarrhœa to wear, even in this country, a warm woolen or silken belt around the abdomen.

Irritation in the intestines may induce, not merely vomiting and diarrhœa, but even general convulsions; and cases are on record of epileptic fits having been produced by the presence of a tapeworm in the intestine, which ceased upon the expulsion of the intruder. Hysterical fits, although their pathology is far from being understood, are now becoming to some extent associated with ovarian irritation; for it is found that, in many cases of hysteria, the ovaries are tender upon pressure, and that the hysterical fit may frequently be instantaneously arrested by pressing upon the ovaries.

We have so far been dealing chiefly with reflex action as a cause of disease, but now we must say a word or two respecting the transference of impressions. It is well known that persons who have had their legs amputated often complain of cold feet, or of pains in their toes, on change of weather. The irritation here is really in the end of the divided nerve in the stump. But the brain is accustomed to refer all impressions made upon a nerve during its course to the terminal filaments from which impressions usually come, just as we feel a tingling in the fingers when we pull upon or jar the ulnar nerve, or, as it is popularly termed, the funny-bone. In disease of the hip, the irritation is felt, not so much in the hip itself, as in the knee.

In headaches one can frequently trace the origin of the pain to some point at a distance from the aching part. Some years ago I met with a case which was to me very instructive. A woman complained of a headache situated in the left temple. One of her teeth at the same time ached somewhat, and I gave her a pledget of cotton-wool, dipped in solid carbolic acid, to put into the cavity. To my disappointment it had little or no effect; but five minutes afterward, on the removal of the cotton-wool to the cavity of a second tooth, likewise decayed, but which had not at first been suspected as the cause of the mischief, the pain disappeared entirely from the temple. Some time afterward I was led to discover an unsuspected decayed spot in one of

my own teeth by a headache in the temporal region. I had noticed that during these headaches there was generally tenderness over the aching part, and that there was also a tender point at some little distance, usually the eye, which was tender to pressure. On this particular occasion, however, there was no tenderness of the eye, and I felt all along the side of the cheek and under the jaw to see if I could discover a second tender spot. Under the ramus of the jaw I found a small gland painful on pressure. As glandular irritation almost always indicates something wrong in the lymphatics which pass to the gland, I at once suspected something in the mouth to be the cause of the tenderness. As there was no abrasion or tenderness of the mucous membrane of the mouth or tongue, I took a pointed instrument and tested each tooth successively. At the very back of the crown of the last molar I detected a small point which was tender upon pressure, and on going to a dentist I was informed that the point was just beginning to decay. Had it not been for the headache this would have passed unnoticed, as the tooth itself had, up to that period, given me no inconvenience whatever. Headache over the eyes, although frequently depending on gastric irritation, is not unfrequently caused by straining the eyes, and is only to be removed by lessening the work which these useful organs have to perform. One finds this headache over the eyes in men who work much with the microscope, or in women who are engaged in fine needlework. Yesterday I met a case of this sort in the surgery. This was a woman who had been accustomed to work about her house, but who began to work at dressmaking three months ago; her hours of work being from 9 A.M. to 9 P.M., with an interval of an hour for dinner in the middle of the day. About two months ago she began to suffer from headache above her eyes, which makes her sometimes feel quite giddy. It gets worse in the evening about seven or eight. The headache here, it will be observed, came on about a month after the eyes had been subjected to this unaccustomed strain; and it became worse in the evening after the darkness rendered artificial light necessary, and thus increased the visual strain.

Having said so much on reflex action as a cause of disease, we will now consider it as a method of cure; and the first instance that suggests itself to our minds is the beneficial effect of a blister. Two theories have been proposed to account for the action of a blister. One is, that it dilates the vessels of the skin in the part to which it is applied, and, by thus drawing away some of the blood from the inflamed organ below, lessens the pain and inflammation in it. The other theory is, that the blister acts reflexly upon the organ itself. The first of these suppositions is very improbable, because the amount of blood in the skin covered by a blister is exceedingly small, and, moreover, does not come from the inflamed organ, with which the blistered piece of skin may have little or no vascular action. The second theory is much the more probable one, but it is not yet certain how the vessels of the

inflamed organ are affected by the blister. We do not know whether they are dilated or contracted. It is most likely, however, that they are contracted, the contraction lessening the pressure of blood upon the inflamed tissues, and thus diminishing the pain in somewhat the same way as we relieve the throbbing in an inflamed finger by holding the hand above the head, or by compressing the brachial artery. This is rendered probable by the experiments of Zülzer, who found that when a blister was applied to the back of a rabbit for a length of time the skin and the muscles immediately below it were red and congested, but the deeper layers of the muscles, the pleura, and even the lung on the same side, were pale and anæmic. There are few inflammations of the internal organs in which blisters to the surface are not serviceable, but much has yet to be done to ascertain the exact points at which they ought to be applied in order to produce their maximum effect. Thus it is said that in sciatica a blister to the heel will sometimes afford relief, while one applied in the neighborhood of the nerve itself has little or no effect.

The effect of poultices is probably different from that of blisters, although ultimately productive of similar relief; for, if we again take the simple instance of a finger inflamed in consequence of a thorn having run into it, we find that we can relieve the pain in two ways, either by putting the hand into cold water or by plunging the finger into a warm poultice. Both of these measures, apparently so dissimilar, will produce a like result in regard to the inflamed point; that is, both will lessen the pressure of blood in the vessels where stasis has already taken place. The cold, applied to the whole of the hand, will cause the arteries leading to the finger to contract, and will thus diminish the supply of blood to the inflamed part, and lessen the pressure in the blocked capillaries. The warm poultice will also lessen the pressure, not by diminishing the flow of blood to the part, but by dilating the vessels around the point of stasis, and affording the blood a ready exit into the veins. In the case of internal organs, the blister applied to the skin probably acts like the cold applied to the finger, while the warm poultice placed upon the surface of the thorax or abdomen affects the deeper lying organs in the same way as it does the superficial ones, the warmth penetrating through the thin thoracic or abdominal parietes. On this account, when we wish to relieve pain in the chest or belly, we ought to make our poultices in a particular way. The common practice of mixing the linseed-meal with hot water, and applying it directly to the skin, is quite wrong, because if we do not wish to burn the patient we must wait until a great portion of the heat has been lost. The proper method is to take a flannel bag (the size of the poultice required), to fill this with the linseed poultice as hot as it can possibly be made, and to put between this and the skin a second piece of flannel, so that there shall be at least two thicknesses of flannel between the skin and the poultice itself. Above the poultice should be

placed more flannel, or a piece of cotton-wool, to prevent it from getting cold. By this method we are able to apply the linseed-meal boiling hot without burning the patient, and the heat, gradually diffusing through the flannel, affords a grateful sense of relief which can not be obtained by other means. There are few ways in which such marked relief is given to abdominal pain as by the application of a poultice in this manner.

Besides blisters and poultices, there is a third class of remedies acting reflexly, which is often too much neglected or despised, but is of exceeding service; I mean plasters. In chronic bronchitis, a plaster on the chest affords great relief, the plaster employed being either the simple pitch one, or the *emplastrum calefaciens* of the British Pharmacopœia. The pain in the chest just under the mamma, which is so often associated with anæmia and leucorrhœa, is relieved in the most remarkable way by the application of a belladonna-plaster, and the same application also relieves when the pain is dependent on organic disease of the heart. The pain in the back, also, which is associated with leucorrhœa and uterine disturbances, is greatly eased by the application of a pitch plaster, or by a strip of *emplastrum calefaciens* placed along the lower part of the spine. In place of this, the *linimentum sinapis*, put upon a piece of spongio-piline four or five inches broad and ten or twelve inches long, has recently been recommended by Dr. Gamgee. The cause of the pain in the back is not known, but Dr. Gamgee's theory is that it is due to exhaustion of the lumbar portion of the spinal cord, that part from which the nerves for the urinary and genital organs are derived. In order to repair this exhaustion, he thinks that the supply of blood should be diminished, because functional activity is usually associated with rapid circulation, while the opposite condition of partial anæmia occurs during the period of rest and repair. To obtain this partial anæmia he employs counter-irritation, differing from that of the blister in being less intense and more prolonged.

Such are a few of the more prominent instances of reflex action, as a cause of disease and a means of cure. To enter fully into all of them would occupy more time than the Society can afford, and to explain them satisfactorily would require more knowledge than I either possess or am able to obtain.—*Brain.*

IS CONSCIENCE PRIMITIVE?

By WARRING WILKINSON.

MR. DUGDALE, in his recent monograph, "The Jukes," has endeavored to show by rather startling statistics how crime and pauperism become hereditary. In this vicious and depraved family, there is a conspicuous absence of moral sensibility—a lack of what we call conscience—that strikes the social scientist as something abnor-

mal. Is not this lack rather a return to normal conditions by the removal of that favorable environment which holds in check the lower instincts, and helps to develop the higher capabilities, of man's nature? Is not that juvenile monstrosity Pomeroy a sort of moral atavism? In short, did the primitive man have a conscience?

And, lest the mere question should shock some good people, let it be premised that the foundations of the Christian religion do not rest upon a belief or disbelief in an innate conscience any more than the popular fallacy of an innate and universal idea of God is a necessary tenet of orthodox faith. These theories form no essential part of religion. They are simply some of the outposts which theologians and schoolmen have erected to strengthen, as they imagine, the citadel of Biblical truth, but forming no part of the citadel itself. These needless defenses have been multiplied in the course of centuries till the thing defended has sometimes been lost sight of. The Fathers have usurped the authority of the Apostles; ancient interpretation ranks revelation. Milton has come to substitute Moses to that degree that so learned a man as Professor Huxley has considered it worth his while to apply the tests of a scientist to the visions of a poet. It must be confessed that time and tradition have lent a sanctity to many articles of popular creed that have little authority in Holy Writ, and the so-called conflict between Science and Religion will have served no ill purpose if in its heat the rubbish of ages is burned away. In this conflict man's fictions may suffer—God's truth, *never*.

In the language of theology the conscience is a separate and distinct faculty of the mind—a sort of Supreme Court to which all cases involving the principles of right and wrong are immediately referred for adjudication and intuitively settled. It is generally asserted that this faculty is congenital—chief justice by birth and divine right. I believe, on the contrary, that this mind faculty is not innate, but, if it exists at all, it is born of the other faculties, is educated to its functions, and, like the late Electoral Commission, reflects its training in all its decisions.

A conscience to justify the popular notions of its origin and authority ought to be infallible, and must be *universal*. If this faculty is an innate and essential part of man's being, it should be in every man, and exercise its functions everywhere. It is admitted that isolated and sporadic cases of deficient moral sensibility do not authorize the logical conclusion that there is no such thing as conscience, any more than the inmates of a blind-school prove that there is no such thing as sight; but if there are found whole tribes of people who not only lack all evidence of a conscience, but whose language has no words to express moral distinctions or ideas of right and wrong; if, in addition, we find that where higher races give evidence in language and life that they have certain moral perceptions, yet that the decisions of conscience always follow local tradition and custom—it seems a fair

inference that the faculty itself is not an essential of man's mental constitution, but is a product of culture; the resultant perhaps originally of observation and experience, which in time, and under the influences of civilization, *may* become an hereditary aptitude, though the facts of deaf-mutism, to which reference is made hereafter, militate against the theory of transmission.

Cœlum non animum mutant qui trans mare currunt[1] is perhaps true of those who are old enough to travel, and who find national habitudes of thought and culture following them everywhere, but morals certainly change with almost every clime and age. In a broad survey of the history of morals one comes to doubt whether there is such a thing as abstract right and wrong. Every article of the religious code in which we have been educated, and which we revere, has been or is violated without remorse among the peoples who sit in darkness, but who are supposed to have that intuitive faculty which makes the pagan a law unto himself. The vice of to-day is the virtue of yesterday: a disgrace in England is a dignity in Ashantee. The crowning glory and triumph of Christian grace is the shame of the red-man's creed. Crimes against life, crimes against liberty, crimes against personal rights, crimes against chastity, crimes against nature, have all been sanctioned and justified by this infallible judge. The bitterest wars have been religious wars, where the contending hosts were stimulated and led on by conscience. The fiercest persecutions have been religious persecutions, where conscience stretched the rack and tightened the thumb-screws. The blood of martyrs stains the skirts of every sect: Catholics have persecuted Protestants, Protestants have persecuted Papists, and both have set their heel upon the Jew. The atrocities of Alva were equaled by the cruelties of Louvois. The victims of St. Bartholomew find a parallel in the sufferings of the Scotch Covenanters. Saul thought he was doing God service in haling men and women to prison and to death. Blood for blood is Hebrew as well as Indian law. The sin of stealing among the Spartans was in being caught at it. The severe Cato thought it right to yield his wife to his friend. Socrates sanctioned the prostitution of Aspasia by his daily intercourse and friendship. In the Balearic Isles a bride was the common property of all the wedding-guests before she could be the wife of one. Among the Naudowossies the woman who could take to her bosom forty stalwart warriors of a night was regarded almost with veneration, and had her pick of the tribe for a husband. Galbraith says that among the Sioux theft, arson, rape, and murder, are regarded as means of distinction. In Tahiti, while idolatry prevailed, the common animal instinct of maternal affection seemed lacking, so much so that Mr. Ellis, long resident there, says he never met a Tahitian mother who had not imbrued her hands in the blood of her offspring. It is not necessary to show that these crimes were ever considered *right*. It

[1] They change their sky, not their affections, who cross the sea.

suffices that they were committed without remorse, without a feeling of wrong-doing. They are not instances of perverted conscience, but of no conscience, and the concurrent testimony of travelers is that the lower races have no moral sense. Mr. Dove says that the Tasmanians "are entirely without moral views" or impressions. Governor Eyre says the Australians have no moral sense of what is just and equitable in the abstract, their only test of propriety being whether they are numerically or physically strong enough to brave the vengeance of those whom they may have provoked or injured. "Conscience," says Burton, "does not exist in eastern Africa, and 'repentance' means regret for missed opportunities of mortal crime." Mr. Campbell observes that the Soors, an aboriginal tribe of India, are without moral sense. Language is a pretty good measure of mental development, yet the dialects of inferior tribes are generally deficient in terms expressive of moral quality. Remorse is absolutely unknown, and Lubbock says the only instance of a man belonging to one of the lower races trying to account for an act is the case of a young Feejeean, who, when asked why he had killed his mother (in law?), answered, "Because it was right."

It is very difficult to get at the original man, for the reason that wherever found he is the heir of all the ages, and the training of circumstance and condition begins away beyond the reach of mind and memory. No man can remember the time when he could not talk or walk. He can not remember when sad experience first taught him that the candle-flame was not just the thing to cut his teeth upon. No more does his memory go back to the time when his first lessons in ethics were enforced by the gentle spat of the mother's hand or the warning "No! no!" of her reproving voice. Humanity forbids repeating the cruel experiment of Psammeticus, who secluded a child from all intercourse with his kind in order to get at the original speech of man. But nature has done what civilization would have no right to do, and offers in the phenomena of deaf-mutism a psychological study of curious interest. Considered from an intellectual and moral standpoint, the deaf-mute is an anachronism—a prehistoric man standing bewildered in the blaze of the nineteenth century. By simple severance of a nerve connection an invisible barrier is thrown around the child, and in this seclusion the mind develops to a certain extent free from the influences of accumulated culture, and is in respect to ethical notions absolutely primitive. The animal instincts are strong, and their gratification sought after the manner of an animal. He appreciates kindness and resents injury. He will steal and hide the thing stolen, but I have seen a dog do the same. He acquires certain ideas concerning the rights of possession, and will commit murder in defense of such right without remorse. In a recorded case near Rodez, France, officers were sent to seize property for debt. They were driving off the peasant's cow, when the farmer's son, an uneducated deaf-mute, seized a club

and brained the officer, and when brought into court could hardly be restrained from inflicting the same punishment upon the constable's assistants whom he recognized there. He was acquitted, on the ground that, being entirely ignorant of the legal rights of the case, he had only obeyed one of the first laws of nature in defending his father and his property.

The uneducated deaf-mute never rises to the conception of a God or Great First Cause. If he reasons at all on the subject, he concludes things have always been as they are, or as one expressed it, "it was natural to be so." He has no idea of a life beyond the grave, nor of future rewards and punishments. The more intelligent will work out philosophies not of creation but of physical phenomena, sometimes strangely like the mythologies of the ancients, and the similarity of these myths indicates how naturally the primitive mind materializes and seeks explanation of phenomena by the generalizations of personal experience. The association of causes is sometimes ludicrous.

An English deaf-mute boy observing that he could raise quite a strong wind with his mother's bellows, naturally concluded that the wind which sometimes took his hat off in the street came from the mouth of a gigantic bellows. He never stopped to inquire who blew the bellows. A little girl imagined that the plants which spring up from year to year in the fields and woods were like those in her mother's garden, planted and watered by "some woman"—an infantile conception, in which, however, may be traced a kindred germ to the old Greek notions respecting nymphs and dryads. One lad, struck by the similarity between flour falling from a mill and snow falling from the clouds, concluded that snow was ground out of a mill in the sky. A more poetical notion was that of a little fellow who thought the soft, feathery snow-flakes in the winter were the falling blossoms of unknown orchards in the sky, of which hailstones in summer were the icy fruit. Some suppose thunder and lightning to be the discharge of firearms in the sky, a notion the converse of that of the Aztecs, who believed the Spaniards were gods armed with thunder and lightning.

Thus it is that human nature repeats itself, and that deaf-mute children left, by their inability to profit by the experience of their elders, in a prolonged infancy exemplify, in their efforts to account for the phenomena of nature, many of the fancies that prevailed in the infancy of society.

But if this primitive mind fails to grasp the idea of a Great First Cause, it is equally clear that ethical distinctions are also lacking; and this belief is supported by good authority among those who have intimate acquaintance with this peculiar class. Abbé Sicard says of the deaf-mute: "As to morals, he does not suspect their existence. The moral world has no being for him, and virtues and vices are without reality." "The deaf and dumb," says Herr Eschke, of Berlin, an eminent teacher, "live only for themselves. They acknowledge no social bond, they

have no notion of virtue. Whatever they may do, we can impute their conduct to them neither for good nor for evil." Herr Cæsar, of Leipsic, corroborates this testimony. "The deaf and dumb," says he, "comprehend neither law nor duty, neither justice nor injustice, neither good nor evil; virtue and vice are to them as if they were not."

The proof of this moral deficiency by deaf-mute testimony is not so easily obtained, for the reason that the deaf-mute early learns by parental discipline to attach certain consequences to certain acts, and, when he becomes educated enough to be questioned concerning moral perceptions, he has forgotten the time when he did not have what he calls conscience, but which is no more like the theological definition of conscience than is the feeling that makes a dog slink away when detected in wrong-doing. I am not prepared to say that animals have no conscience; indeed, I am quite sure they have the same kind of inward monitor that an uneducated deaf-mute has: child and pup are alike restrained by severe tones and a switch, only the pup learns the most readily. You can teach a hungry dog to watch a piece of meat quicker than a child can be brought to resist the temptation of stealing cherries. Both respond to the gentle culture of caress and kindness, though the dog is the more boisterous in his acknowledgments. Indeed, every parent who has watched the development of an infant must have noticed how like the means used in training animals is the method of child-education. There are the same warning tones, the thwarting of desires, the resort to punishment, and the smiling face, the nod of assent, the rewards of well-doing, and the petting of approbation. With the child there is much iteration of reference to right and wrong; but it is the rewards and punishments which he understands, and not the wordy appeal to the higher motives.

That this is true of the uneducated deaf-mute naturally follows from his peculiar symbols of thought. He thinks in images, and the signs he makes grow out of and represent these images. His ideas are concrete, in the sense that he seldom arrives at general conclusions, his judgment being exercised on particular cases that have fallen under his observation, and which he recognizes when they occur again. Morality is an abstraction that goes beyond the reach of his instruments of thought, and it is only as he comes within the larger capacities of the sign-language as developed and used in institution-life that he can be brought to the level of spiritual conceptions, and to do this we have continually to make stepping-stones as it were out of his own crude and imperfect mental imagery. In this respect the deaf-mute does not differ from the many lower races whose language is so wanting in expressions for spiritual truths that missionaries are obliged to use the most material words from the meager vocabularies of the savages to express their novel messages of mercy and peace.

That what we call the dictate of conscience is only another name for an act of judgment and reason, seems evident from the difficulty one

has in deciding as to what is right and what is wrong. A lawyer may have pronounced upon certain common points of law so frequently that when a case is presented he does not stop to think, but gives answer immediately, yet one would not say that he acts intuitively. So in what might be called the grosser matters of morals the judgment is able to act quickly from frequent exercise, but, when it comes to the nicer distinctions of ethics, so far from acting intuitively or quickly, the mind is often in long and painful doubt. To tell the truth seems to be a plain duty, yet who would dare to condemn Sister Surplice's lie in defense of poor Jean Valjean? "Thou shalt not steal" is human and divine law, but shall a man starve rather than take a loaf of bread that does not belong to him? When does manslaughter in self-defense become justifiable? The relative duties to God, to self, and society, to family and friendship, require much weighing of motive, and evidence, and interests, which, so far from being settled intuitively, call for the most careful exercise of judgment.

The limits of time and space forbid a further discussion of this subject beyond the following summary of conclusions:

1. That examination of minds nearest to primitive conditions shows that there is an utter absence of moral feeling, and that therefore conscience is not a congenital faculty.

2. That the idea of duty is an abstraction, which comes with considerable development of mind and a power of generalization of which the lower races are not capable.

3. That what is called "conscience" is simply an act of judgment and reason.

4. That the decisions of conscience depend upon the education of the individual; and—

5. That therefore conscience, even among intellectually developed races, is not an infallible guide, but must itself be guided by a written law.

FIRES AND THEIR CAUSES.

THE oft-repeated words, "Cause unknown," appended to the daily reports of the conflagrations which occur all over the country, furnish matter for grave reflection. A glance at the report of one of the largest fire brigades will show us that the causes (when ascertained) are of the most varied description. It appears that the candle is the most destructive weapon to be found in an ordinary household, for conflagrations lighted by its help far outnumber those credited to any other cause. Curtains come next on the black list. The next large figures are given to "Spark from fire," followed by "Foul flues." Next in order may be noticed "Gas," "Children playing with fire,"

"Tobacco-smoking," "Spontaneous ignition," and lastly "Incendiarism."

There is no doubt that many a fire owes its origin to causes quite beyond the control of the tenant of the house in which it occurs, and that the scamping manner in which builders' work is often done is the prime cause of many a fire which is put down as unaccounted for. The ends of joists are left protruding into chimneys, or a thin hearthstone is set upon a bed of timber. In both cases the wood becomes so dry and hot that it is ready to take fire from the first spark that settles near it. Overheated flues represent a source of danger which is also attributable to the careless builder; for, if the flue were so placed that its hear could not affect adjacent woodwork, it would be always as safe when hot as when cold. It is true that by act of Parliament builders are obliged to preserve a certain distance between flues and timber; but surveyors can not always reckon on their instructions being carried out, and cases are unfortunately rare nowadays where workmen will do their duty in such matters without constant supervision. Lath-and-plaster divisions between houses are also illegal; but buildings, and more especially warehouses, are now of such vast extent that they really represent aggregations of small houses in which the act of Parliament concerning party-walls becomes a dead-letter.

Among the ascertained causes of fire are those which occur in the various workshops where hazardous trades are carried on. These naturally show an increase since steam-power has become such a universal aid to nearly every kind of human labor; necessitating furnaces which remain kindled for weeks or months together. Apart from this source of risk, there are numerous trades where such inflammables as turpentine, naphtha, spirits of wine, and combinations of them in the form of varnishes, are in daily use to a very large extent. The familiarity which such constant use provokes breeds a contempt which often resolves itself into a negligence almost criminal in its nature. Drying-stoves afford another dangerous item in the list of fires connected with the trades; japanners, cabinet-makers, and hosts of others using such stoves as a necessity of their business. Hot-water pipes for heating purposes also represent the cause of a large number of fires, the most dangerous kind being those which are charged with water and hermetically sealed. The reason of this is easily explained. Water boils at a temperature far below that necessary to ignite woodwork; but, when confined in such pipes as we have described, it will rise in temperature to an extent only measured by the strength of the material which holds it. A soft metal plug is sometimes inserted in these pipes, so that, should any unusual degree of heat be approached, it will melt out, and thus relieve the pressure; but such a good precaution is by no means universal.

The pipes which are used for carrying off heated air, and which are placed above gas-burners, are too often allowed to pass between the ceiling and the floor above without any regard to the obvious danger in-

curred. The various close stoves which were introduced to public notice at the time when the price of coal was suddenly doubled, although no doubt economical, are not so safe as the old form of kitchen range, which many a careful housewife has likened to a cavern. The whole of the air which rises through the flue of a closed stove actually passes through the fire, and thus attains a very exalted temperature. In the old stoves, on the other hand, the hot air is always largely diluted with that which is attracted to the chimney from all quarters. It is evident, therefore, that the chances of fire in the flue of the former are much greater than in that of the latter.

Theatres may be said to combine within their walls all the risks which we have as yet alluded to, for they represent factories where work of a most diversified kind is carried on, and where both open and closed fires are in constant use. At pantomime time especially, the number of persons employed in the various workshops of large theatre is to the uninitiated quite marvelous. Carpenters and "property-men" (those clever workmen who can make everything from a bunch of carrots to a parish pump) represent a constant source of danger from fire, in that they deal with inflammable material, and require the aid of heat for their size and glue. It is obviously important in a little kingdom where all is make-believe—where the most solid masonry is wood and canvas, where the greenest trees are dry as tinder, where even limpid streams are flimsy muslin, nay, where the moon itself is but a piece of oiled calico—that there should be no mistake about the reality of the precautions against accidental fire. In most theatres, rules are in force of the most stringent character, extending even to such details as clearing so many times a day the accumulated shavings from the carpenter's shops. If such a sensible law were enforced in other places besides theatres, it would be a preventive measure of very great value.

Shavings are perhaps the most dangerously inflammable things to be found about a building. A block of wood is a difficult thing to set on fire; but, when reduced to the form of shavings, a mere spark will turn it into a roaring fire. The same thing may be said in a minor degree of a lump of iron, which when reduced to filings can be burned in the flame of a common candle. It is often this difference of bulk which will decide whether a material is practically inflammable or not. Paper affords another example of the same principle: tied tightly in bundles it may smolder, while in loose sheets its inflammability is evident.

It is stated upon good authority that in one third of the number of fires which occur the cause is not ascertained. The plan long ago adopted in New York, and which has led to a sensible diminution in the number of fires there, has not, for some reason, found favor with the authorities in this country. We allude to the custom of convening a coroner's court to inquire into the origin of every fire which takes place. There is little doubt that such inquiries would educate thoughtful householders into taking precautions which might not otherwise

strike them as being at all necessary. The importance of such precautions is manifest when we learn that in London alone there are on the average three fires in every twenty-four hours. If this wholesale destruction were reported of an Eastern city, where the houses are of wood, and are sun-dried by incessant tropical heat, there would be some excuse for it. But here at home, where bricks and mortar are so common, it is certainly astonishing that fires should be so prevalent.

It would seem that it is a much easier task to set an entire house on fire than it is with deliberate intention, and with proper combustibles, to light a stove for the purpose of boiling a kettle. This latter operation is not so simple as it appears to be, as any one may prove who has not already tried his or her hand at it. In fact, an efficient or bad house-servant may be almost at once detected by the ease or difficulty with which she lights her fires. The inefficient servant will place some crumpled paper in the grate, and will throw the best part of a bundle of wood on the top of it, crowning the whole with a smothering mass of coal ; and will expect the fire to burn. The good servant will, on the other hand, first clear her grate, so as to insure a good draught; she will then place the wood above the paper, crossing the sticks again and again ; then the coals are put in deftly one by one, affording interstices through which the flames will love to linger ; a light is applied ; and the kettle will soon be singing acknowledgments of the warm ardor with which it has been wooed. Contrast this with the other picture, where double the fuel is wasted, and where smoke and dirt make their appearance in lieu of tea and toast. We venture to say that a badly managed kitchen fire, with its train of unpunctual meals, leads to more general loss of temper than all the other minor domestic troubles put together. The stove is usually the scapegoat on which the offending servant lays her incompetence (the cat clearly could establish an *alibi*) ; but the most perfect of ranges would not remedy the fault. The only real reason for such a state of things is the prevalence of sheer stupidity. Molly's mother was taught by Molly's grandmother to light a fire in a certain way, and Molly's descendants will, from persistence of habit, continue to light fires in that manner, be it good or evil, until the end of time. It is quite clear that the same stupidity which causes an intentional fire to fail will occasionally lead to a pyrotechnic exhibition which has been quite unlooked for. For instance, cases are not unknown where servants have used the contents of a powder-horn for coaxing an obstinate fire to burn; the loss of a finger or two generally giving them sufficient hint not to repeat the experiment.

The general use of gas has done much to reduce the number of conflagrations, for it has replaced other illuminators far more dangerous ; but it has at the same time contributed a cause of accident which before its use could not exist. So long as people will insist on looking for an escape of gas with a lighted candle, so long will their rashness be rewarded with an explosion. It is not customary, where there is a doubt as to

whether a cask contains gunpowder or not, to insert a red-hot poker into the bung-hole. Yet such a proceeding would be scarcely less foolhardy than the detection of the presence of gas by means of flame. The test in both cases is most thorough, but it is too energetic in its action to be of any value but to those who wish to rise in the world too suddenly.

Drunkenness is a well-known source of burned-out dwellings, the habitual tippler being too often left to his own devices in the matter of matches and candles. The usual faculty of double vision with which an inebriated man is gifted leads to a divided claim upon the extinguisher, which naturally points to a disastrous sequel. Even sober people will be guilty of the most hazardous habits, such as novel-reading in bed with a candle placed near them on a chair; for novels, like some other graver compositions, are occasionally apt to induce slumber; and the first movement of the careless sleeper may imperil his life, as well as the lives of others who may be under the same roof with him.

The caprices of female dress have also often led to fatal accidents from fire, and crinoline skirts had in their day much to answer for. But at the present time petticoats seem to have shrunk in volume to the more moderate dimensions of an ordinary sack, so that we are not likely to hear of accidents from this particular cause until some fresh enormity is perpetrated in the name of fashion. We may mention in this connection that tungstate of soda (a cheap salt) will render muslins, etc., uninflammable. But strange to say it is not generally adopted, even on the stage, where the risks are so multiplied, because it is said to prevent the starch drying with due stiffness! We have all heard of what female courage is capable when little ones are in danger, but we hardly thought that it was equal to the task of risking precious life for the appearance of a muslin dress. We can only bow, and say—nothing.

Where fires have been traced to spontaneous combustion, it has generally been found that some kind of decomposing vegetable matter has been the active instrument in their production. Cotton-waste which has been used for cleaning oily machinery and then thrown aside in some forgotten corner, sawdust on which vegetable oil has been spilt, and hemp, have each in its turn been convicted of incendiarism. The simple remedy is, *to avoid the accumulation of lumber and rubbish in places where valuable goods and still more valuable lives are at stake.* Occasionally fires have been accidentally caused by the concentration of the sun's rays by means of a lens or of a globe of water, and opticians have for this reason to be very careful in the arrangement of their shop-windows. A case lately occurred where a fire was occasioned, it was supposed, by a carafe of water that stood on the center of a table. The sun's rays had turned it into a burnnig-glass! It is stated, with what amount of truth we can not say, that fires in tropical forests are sometimes caused by the heavy dewdrops attached to the foliage acting the part of lenses.

The advance which has been made during the last twenty years in all appliances connected with the art of extinguishing fires has done much to limit or rather localize the dangers of such catastrophes; for, whereas in the old days the lumbering "parish squirt" was the only means of defense, we have now in all large towns steam fire-engines capable of throwing an immense stream of water with force enough to reach the topmost floors of very high buildings. The aforesaid "squirt" was capable of little more than wetting the outside of contiguous buildings, with a view to prevent the spread of the original fire, which generally burned itself out. But now our engines furnish a power which will often smother a large fire in the course of half an hour or less. Moreover, our well-organized fire brigades are trained to convey the hose to the nucleus of the flames, and much heroism is shown in the carrying out of this dangerous duty.

And now for a few simple precautions.

Let some member of the family visit every portion of the house before it is shut up for the night. (While he is seeing to the safety of the fires and lights, he can also give an eye to bolts and bars, and thus fulfill another most necessary precaution.) See that there is no glimmering of light beneath the bedroom doors for any unreasonable time after the inmates have retired to rest. Insist on ascertaining the cause of any smell of burning. It may be only a piece of rag safely smoldering in a grate, but satisfy yourself upon the point without delay. Do not rake out a fire at night, but allow it to burn itself out in the grate. (We have already referred to the danger of hearthstones set upon timber.) Do not allow an unused fireplace to be closed up with a screen unless it is first ascertained that there is no collection of soot in the chimney, and no communication with any other flue from which a spark may come. Caution servants not to throw *hot* ashes into the dust-bin. Let the slightest escape of gas be remedied as soon as possible, and remember that the common form of telescope gasalier requires water at certain intervals, or it will become a source of danger. Finally, forbid all kinds of petroleum and benzoline lamps to be trimmed except by daylight. (A lamp was the initial cause of the great Chicago fire.)

Many other precautions will suggest themselves to the careful housekeeper. But, after all, the best precaution is common sense, which, however, is the least available, being the misnomer for a faculty which is far from common.—*Chambers's Journal.*

THE SUN'S LONG STREAMERS.

PROFESSOR CLEVELAND ABBE, an American astronomer and meteorologist, who had intended to observe the eclipse of the sun last July from the summit of Pike's Peak, in Colorado, more than 14,000 feet above the sea-level, fell ill after he had reached that place, and was carried down to the Lake House (elevation 10,000 feet), there to remain while the rest of his party staid to view the eclipse from the summit. Probably if he had remained with them his observations would have differed in no very marked degree from those which other astronomers made on that occasion. He would have devoted a few seconds, perhaps, to the study of the sun's corona with the naked eye. He would probably have made some telescopic, spectroscopic, or polariscopic observations during the rest of the three minutes during which the total eclipse lasted, and possibly he might have noted some feature rather more effectively and satisfactorily than most of the other observers. But under the actual circumstances he could not hope thus to take his place among the thousands of observers who have noted the phenomena of total solar eclipses. He had no optical or other instrument. Worse than all, he is near-sighted; and, though he had a pair of spectacles, it was not quite strong enough to correct his near-sightedness.

Yet Professor Abbe succeeded in making observations far exceeding in interest any which were made by the entire force of eclipse observers in 1874 and 1875, and fairly comparable in this respect with the most remarkable discoveries effected during the great eclipses of 1868, 1869, 1870, and 1871. Debarred from instrumental researches, unable to do what most observers of eclipses seem anxious to do—namely, to see everything that can be seen—he was compelled to restrict himself to precisely that line of observation which we indicated eight years ago as likely to be most instructive. He gave his whole attention to the corona, and especially to its outlying and feebler portions. Studying the phenomena with the naked eye, or at least with only spectacles to aid him, he could recognize faint luminosity which the telescope would inevitably have concealed from his view. He was not hurried; nor was he disturbed by the thought that such and such instruments must be attended to in turn while still totality lasted, with care also that in the darkness nothing should be disturbed or injured. As he said after the observations were completed, and as we pointed out in 1870, "a glance of a few seconds will no more suffice to do justice to the delicate phenomena" (of the corona) "than it would suffice to enable a naturalist to draw the distinguishing features of a new shell or insect, or would enable an artist to correctly sketch in a landscape."

Before describing what Professor Abbe actually saw, it may be well to indicate first the nature of the observations he proposed to make, and

secondly his preconceived ideas as to what he was likely to see, for otherwise the value of his observations will not be fully appreciated.

Our readers may perhaps remember that in the year 1870 a discussion took place on the question whether the glory of light seen around the sun during total eclipse belongs to the sun or not. There were those who maintained very confidently the opinion that this glory is either a purely optical phenomenon only or else is due to the passage of the solar rays through our own atmosphere all round the place of the eclipsed sun. On the other hand, there were some (ourselves among the number) who pointed out that the corona must necessarily belong to the sun, since its features could not possibly be reconciled with any other theory. The greater number of astronomers seemed, however, to form no opinion one way or the other, but to prefer to leave the matter to be decided by fresh evidence. For too many imagine that the best way of showing how greatly they value observations is by declining to investigate the full significance of observations already made.

It will be remembered that before long the new observations devised to settle a question which had been abundantly answered by observations already made proved unmistakably the solar nature of the corona. Photographs were taken during the total eclipse of December, 1870, and in greater number during that of December, 1871. On the latter occasion photographic views of the corona taken at stations far apart agreed closely together, showing that the corona could not possibly be an atmospheric phenomenon. No one could imagine that the air above Baicull, where Mr. Davis (Lord Lindsay's photographer) took his views, could by some amazing accident produce coronal features resembling those produced by the air above Ootacamund, one station being close to the seashore, the other hundreds of miles inland and some 10,000 feet above the sea-level. On the other hand, the resemblance of the several views taken at either station showed that the coronal glory could not be due to the illumination of some matter on the hither side of the moon, but far outside our own atmosphere. For the solar rays, passing athwart the lunar disk to fall upon such matter, would shift rapidly in position as the moon moved onward, so that the features seen at the beginning of total eclipse would differ markedly from those seen toward the end. Since the six pictures taken at Baicull closely resembled each other, as did the six taken at Ootacamund, so that all twelve views represented the same corona (though of course not all to the same distance from the sun), it was manifest that the corona then seen was a solar appendage. The actual distance to which the corona can be traced in these pictures corresponds to about 900,000 miles.

But the believers in an atmospheric corona were not even yet wholly satisfied. Nay, before the recent total eclipse one among them even went so far as to say that the observations and photographs of 1870 and 1871, while demonstrating the solar nature of the glory immedi-

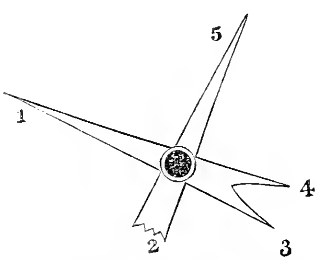
ately surrounding the sun, proved the long rays extending much farther from the sun to be non-solar phenomena. "The non-solar origin of the radial structure," said Mr. Lockyer as late as July 20th last, "was conclusively established" during the eclipse of December, 1871.

To say the truth, there is no possible way of interpreting the long rays as phenomena of our own atmosphere or of matter (gaseous, meteoric, or dust-like) on the hither side of the moon. The idea is one which mathematicians may casually have thrown out. Indeed, Mädler and Airy, after the eclipse of 1860, advanced the hypothesis that the long rays belong to matter between us and the moon, while Sir John Herschel adopted in his "Familiar Lectures" the notion that these rays belong to matter at a great height in our own atmosphere. But it would be to misrepresent these eminent astronomers to assert that they ever *maintained* these views. The available evidence, analyzed as any one of these mathematicians could have analyzed it, had he seen fit, would have shown convincingly that the rays must come from matter lying far beyond the moon. Sir John Herschel admitted this in a letter addressed to the present writer. Whether Airy or Mädler ever examined the evidence closely we do not know. If they did they doubtless were led to the same result as Sir J. Herschel. The matter may be put in this way: Since these long rays extend from the black disk of the moon during mid totality, they occupy then a part of the sky where no sun-illuminated air lies at such a time; therefore they cannot belong to our air; but if there were some very tenuous matter, aërial or dust-like, extending as far as the moon's orbit, the whole region of the sky athwart which these rays extend would contain matter of this sort under full solar illumination; no rays then would be seen, but a nearly uniform glare, which should become brighter and brighter as the distance from the sun's place increased. If we add to this that at midnight the whole of the sky, except a round spot some four or five times the diameter of the moon, would be occupied by this cis-lunar matter under direct solar illumination, instead of that illumination from behind which such matter would receive during total eclipse, we see that the darkness of our midnight sky speaks as decisively against this theory as does the brightness of the long rays seen during total eclipse.

Notwithstanding the overwhelming evidence available to show that these rays lie far beyond the moon, Professor Abbe had adopted the opinion that the rays belong to the earth's atmosphere, or else are mere optical illusions. "I had hitherto firmly believed them," he says, "to be either in the earth's atmosphere or in the observer's eyes. . . . Such rays," he adds, "were seen by members of my eclipse party at Sioux Falls City, Dakota, August, 1869; but at that time and ever since I have doubted their existence." It is manifest that he did not begin his observations with the preconceived idea that the rays belong to matter far more distant than the moon, but with a strong opinion, if not a strong prejudice, the other way.

Next let us consider the actual circumstances under which he observed the eclipse, for they also are important in enabling us to estimate the value of his result. "Having been somewhat hastily carried," he says, "from the summit of Pike's Peak down to the Lake House (elevation 10,000 feet), I had by Monday noon recovered sufficiently to be laid on the ground upon a gentle slope facing westward, where I studied the rays visible about the sun during totality. I had no optical or other instrument, and unfortunately had only a pair of spectacles not quite sufficient even to correct my near-sightedness. By straining my eyes somewhat I was, however, able to do something. My whole attention was given to the rays that extended beyond the brilliant ring which I presume represents the true solar atmosphere. I was undisturbed by any other consideration except to get a true presentation of these rays. . . . I went over the region around the sun again and again—at least six times—leisurely during the 161 seconds of totality, and cannot doubt the truthfulness and fairness of my drawing and description. . . . Two stakes were driven down on either side of me; and between them was placed a rotable axis, on which my drawing-board and paper were fastened. . . . By slightly tipping my drawing-board I kept the sun just above it, or just hidden from view, as I wished, while I drew in such details as I wished, and that too, as it seemed to me at the time, with great ease and accuracy, especially as to the angular position of the rays."

The moon or sun appeared surrounded by a narrow brilliant white ring, less than 140,000 miles broad. (We alter the technical indication of apparent breadth into the actual breadth in miles, as likely to be more intelligible to most of our readers.) This ring was as brilliant as the full moon. It was of uniform tint and light, continuous and without any break or structure visible to Professor Abbe. "Outside of this there was no other concentric coronal appearance, and no external boundary; but the immaculate blue-black sky immediately adjoined this light, which I now call the true solar corona or atmosphere." There was throughout plenty of light to read and write by, though very different from that given by the full moon.



Illustrating the Rays seen round the Eclipsed Sun by Professor Abbe.

The picture which accompanies Professor Abbe's description in the "Colorado Springs Daily Gazette" is doubtless not intended to present with any accuracy the actual tints or degrees of brightness of the various features observed. The shape of the streamers is shown with sufficient exactness in the accompanying figure. It will be understood, of course, that the rays numbered were seen on a dark background, the "immaculate blue" of Abbe's description.

The tapering ray marked No. 1 was the first seen by him. He says he saw it on his first glance at the corona. It then seemed to extend about three times the diameter of the sun; but in a minute or so, as the observer's eyes became accustomed to the sight, he was able to trace its tapering end to a distance of six diameters of the sun's disk. "Its sides were straight lines, its axis passing slightly below the sun's center. Its light was an exceedingly faint and delicate white, apparently overlaid or intermingled with the blue of the atmosphere. I saw no striation, texture, or variation of light. There was no decided increase of brightness in that part of the ray near the sun's edge, nor in the axis of the beam, the delicate light continuing uniform up to the corona, in whose glare it was lost." We must note here two points. In all probability the words "in a minute or so" are used in their colloquial sense for *presently*, because the whole totality did not last two minutes and a half, and in the course of that time Professor Abbe noted all the features of the corona six several times. Secondly, we find that, both in the "Daily News" and in "Nature," Professor Abbe is described as tracing the rays to a distance of six degrees from the eclipsed sun, not six diameters only; so that, as the sun's apparent diameter is little more than half a degree, these accounts would suggest that he saw the rays to double the distance described in the "Colorado Daily Gazette." But there seems little reason to doubt that the accounts given in the "Daily News" and "Nature," which constitute in reality but one account, seeing that they both came from the same source, are incorrect; for the account sent to the Colorado paper was written by Professor Abbe himself. It contains an illustration from a drawing of his own (reproduced above), which agrees with his description. Moreover, we received the paper directly from Professor Abbe; and unquestionably he would have struck out the word "diameters" and substituted "degrees" if he had really seen the ray extending to the greater distance. Note also that the word "diameter" is used throughout the descriptions of other rays.

The ray marked 2 was seen as soon as 1. Its bounding edges, diverging from each other, but not from the sun's center, produced a somewhat fan-shaped ray. "When first seen," says Abbe, "I estimated its outer limit at one diameter, but subsequently traced it to a diameter and a half from the sun. Its left-hand edge appeared somewhat sharper and brighter than the right-hand edge. With this exception the light was very uniformly distributed throughout its surface, fading away rapidly at its outer end. It also remained changeless throughout the totality."

No. 3 was also seen at the same time as No. 1. "It was narrower and shorter than No. 1: its estimated length, three diameters. It broadened at its base, like No. 1, and had the same uniform tint and intensity."

No. 4 "was not noticed at all until the totality was half over. Its

length was one diameter, and it was certainly brighter at the end farthest from the sun. It remained perfectly steady," adds Professor Abbe, "after I once noticed it, and gradually I became aware of a faint light partially connecting it with No. 3, so that the final impression left on me was that these two constituted one fan-shaped projection similar to No. 2, but fading out in the central portions. The axis of No. 1 and of Nos. 3 and 4 passed nearly, if not exactly, through the sun's center.

No. 5 extended fully five diameters from the sun's limb, "and was in all respects similar to No. 1. Its base was broader than that of No. 1, which I attributed," says Abbe, "to the glare of the increasing corona" and of a mound of the ruddy prominence matter (low-lying, so as to form only an extension of the sierra). The light of No. 5 was fainter, Professor Abbe thought, than that of No. 1. "Its edges were straight, except in so far as the coronal glare appeared to unduly broaden the base. Its axis passed very nearly through the sun's center, and was in the prolongation of the axis of No. 2."

Professor Abbe's explanation of these rays or streamers occurred to him an hour or so after seeing them. He advances it as one which "will probably result in the overthrow of all previously entertained theories respecting the character and cause of these streams of light." But in reality it is not nearly so novel as he seems to imagine. It is, indeed, partly new, and in our opinion it is in great part true; but what is true in it is not new, and we question greatly whether what is new in it can possibly be true. Let astronomers judge.

"Meteor streams," says Professor Abbe, "is the key to the solution—not such meteors as some suppose to be falling into the sun daily, but the grand streams of meteors that cause the numerous shooting stars of August and November, and of the existence of which there is indubitable proof. These streams consist of fine particles or pieces, each a long way from its neighbor, but all rushing along in parallel orbits about the sun, like the falling drops of rain in a thunder-shower. The August stream is calculated to be several hundred thousand miles broad and thick, and many million miles long. Such a stream, when far beyond the sun, but still lighted up by it, would reflect to us a faint uniform light precisely like that of these rays. If one end of the stream were farther from us than the other, the effect of the perspective would be to produce a tapering or wedge-shaped appearance. In some other part of our orbit, or with the meteor stream in some other part of its orbit, the perspective might vanish and the two ends appear of the same width. In this way we shall undoubtedly be able to explain the very numerous historical and memorable occasions on which flaming coronas, swords, comets, etc., seen in the sky during a total eclipse have been regarded by the superstitious as divine omens."

We have very little doubt that the great extension of the corona in certain directions during many total eclipses, and the probably far greater extension of a fainter, not readily discerned lustre during all

eclipses, is due to the existence of meteor streams. It is also undoubtedly true that several of the meteor systems encountered by our earth in her journey round the sun have the vast dimensions mentioned by Professor Abbe. Indeed, he far underrates the dimensions of the August and November meteor systems, each of which must be measured in length by hundreds of millions of miles, not by mere millions. But it is absolutely impossible that any of the meteor systems traversed by our earth, or any meteor systems of no greater degree of richness, should present the appearance of streamers surrounding the sun, like those in our figure above. So far as the two systems specially mentioned by Professor Abbe are concerned, inasmuch as we know the exact shape and position of the orbits along which the meteors forming these systems travel, we can determine the exact position which the meteoric streams occupy in the heavens at any moment; and most certainly neither of them on July 29th last occupied the position of the two beams shown across the sun in our figure. The August system was the one which at the time passed nearest to the sun's place on the sky, but it did not come within several degrees of the sun. The November system did not even cross the part of the sky where the sun was. These two systems, therefore, could not possibly be connected in any way with the two streams, of whatever nature, which produced the rays intersecting exactly at the sun.

But there is a more general objection to the theory that such meteor systems may explain coronal streamers seen during total eclipses of the sun. If such streams could be seen when situated beyond the sun, they would be seen far better when opposite the sun on the dark background of the midnight sky. Take, for instance, the November meteors. We know that the flight of meteors, some 2,000,000,000 of miles long, which the earth traversed in November, 1866, 1867, 1868, 1869, 1870, and 1871, is now nearing the remotest part of the long orbit of the November system, many millions of miles beyond the path of Uranus. We know that at midnight in winter the richest part of that system lies due south, at an elevation varying from 30° to 50° above the horizon. There, illuminated fully by the sun, though at a great distance from him, it ought to be far better seen than a similar system lying beyond the sun and visible only through the light of the brightest part of the corona. But no one has ever, on the darkest and clearest night and under the most favorable atmospheric conditions, even suspected the existence of the faintest possible light where the heart of the November system is really situated. Much less, then, could such a system be seen during total eclipse (if so situated as to lie athwart the sun). Systems less rich than the November system (the richest known to us) would have still less chance of being discerned.

If, then, we are to account for the radial streamers seen by Professor Abbe, and also seen during many other total eclipses, though to a less distance, by the meteoric theory, we must consider meteor systems

very unlike those through which the earth herself passes. The meteor systems required by the theory must be much denser and much more brightly illuminated than the August and November systems. To say they must be much more brightly illuminated is equivalent to saying that they must be much nearer the sun. And in this we see an escape from another difficulty. Meteor systems very near the sun would be far more likely to appear as streamers extending radially from him than systems at a great distance from him. A distant system might, by a mere chance, so appear. For instance, if a total eclipse of the sun had occurred on or about May 10, 1865, the November meteor system (whose richest part was then crossing the earth's track at the point she occupies on November 13th) would have appeared, if discernible at all, as a streak athwart the sun's place in the sky, and therefore forming two rays on opposite sides of him, somewhat like 2 and 5 in our figure. Sixteen years or so earlier or later the November system would present a similar appearance, only very much fainter, on account of greatly increased distance, during a total eclipse occurring on or about November 13th. At no other time in the year except November 13th and May 10th, or about these dates, could the November system present such an appearance. But a system traveling close to the sun, and not far from the plane near which all the planets travel, would present at all times nearly the appearance of a pair of rays like 2 and 5 of our figure. On this account, therefore, as well as on account of the greater brightness with which such meteor systems would be illuminated, we must prefer the theory that the systems to which the coronal rays are due travel near to the sun.

Yet, even as thus presented, the meteor theory alone seems inadequate to explain the coronal streamers. There is an enormous mass of evidence showing that meteor systems are most richly strewed throughout a region around the sun, extending nearly to the distance of the planet Mercury; but there is also abundant reason for believing that these multitudinous systems would present an appearance very different from that depicted in Professor Abbe's view of the coronal streamers. We want something quite distinct from the theory of a mere aggregation of meteors to account for these rays, whether pointed or fan-shaped, extending directly from the sun. The aggregation of meteors might present the appearance of a luminous cloud around the place of the eclipsed sun. This cloud might be to some degree radiated, because each meteor system would have a course carrying it either directly athwart the sun's place on the sky, or nearly so. But there would be nothing like those sharply defined streamers extending separately from the sun to distances of ten or twelve sun-breadths. Sir George Airy, describing the appearance of the corona during the eclipse of 1851, pictures just such a cloud as we should expect to result from the aggregation of meteors. "Its color," he said, "was white, or resembling that of Venus; there was no flickering or unsteadiness; it was not separated

from the moon, nor had it any annular structure : it looked like a radiated luminous cloud behind the moon." The long streamers manifestly require a different explanation.

We can not but think that the true explanation of these streamers, whatever it may be (we are not in the least prepared to say what it is), will be found whensoever astronomers have found an explanation of comets' tails. These singular appendages, like the streamers seen by Professor Abbe, extend directly to the sun, as if he exerted some repellent action on the matter forming the heads of comets. Indeed, Sir John Herschel did not hesitate to say that the existence of such a repulsive force was, to all intents and purposes, demonstrated by the phenomena of comets' tails. Now we know that meteors and comets are in some way associated, though the actual nature of the connection between them is not clear. It is certain that the November meteors, the August meteors, and other such systems, follow in the track of known comets. We know that when, in 1862, the earth passed through the region of space along which Biela's comet had recently traveled, there was a display of thousands of meteors, all radiating from just that part of the heavens from which bodies traveling parallel to the orbit of Biela's comet would have seemed to radiate. It follows from this association between comets and meteors, and from the fact that probably thousands of meteoric and cometic systems travel close to the sun, that in all probability there must exist generally, if not always, in the sun's neighborhood, enormous quantities of the substance whence comets' tails are formed by the sun's repellent action. This being so, we should expect to find generally, if not always, long streams of matter extending from the sun's immediate neighborhood, in the same way that comets' tails extend from comets' heads. Whether the repulsive force is electrical, magnetic, or otherwise, does not at present concern us; or rather it does concern us, but at present we are quite unable to answer the question. All that we know certainly is that, in the first place, the sun does in some way cause streams of luminous matter to appear beyond the heads of comets, in a direction opposite to his own, and to enormous distances ; and, in the second place, that the matter forming comets' heads is probably present at all times, in large quantities, in the sun's immediate neighborhood. We can hence infer, with extreme probability, that such long streamers as Abbe saw last July, Myer in August, 1869, Feilitzsch in June, 1860, and several Swedish observers during the eclipse of 1733, are produced in the same way as comets' tails, and therefore really extend (as they seem to do) radially from the sun. It is also certain that if they did not really extend radially from the sun, their always seeming to do so would be altogether inexplicable. So that the theory to which we are led in one direction leads us also out of what would else be a very perplexing difficulty in another direction.—*Cornhill Magazine.*

SKETCH OF CHRISTIAN GOTTFRIED EHRENBERG.

By FREDERICK HOFFMANN.

AMONG the pioneers and master minds in the domain of natural science, during the first half of the nineteenth century, several have risen far above their contemporary co-laborers, and have attained to heroic prominence; while a few, transcending the limits of their own period, have largely contributed to giving shape and character to their time, opened and entered upon novel paths or new fields of inquiry, and thereby have immortalized their life-work, and their name in history's imperishable record. Among these sovereigns of science ranks Christian Gottfried Ehrenberg, whose labors and researches for more than sixty years have connected his name with the most illustrious scientific discoveries of modern times.

Ehrenberg was the son of a Lutheran minister, and was born April 19, 1795, at Delitsch, in Prussia. Having received a classical education at home, and at the famous Schulpforte Gymnasium, he entered the University of Leipsic in 1815 as a student of theology. During the three years' course of theology, he also occupied himself with the study of natural sciences, and, through his increasing interest in the wonders of the creation, took up the study of medicine in 1818 at the University of Berlin, then as now the greatest and foremost of German universities. His efforts and researches were soon directed toward the investigation of the minute organisms and the ultimate forms and phenomena of organic life. Since the time of that first remarkable triumvirate, Malpighi, Grew, and Leeuwenhoek, who toward the close of the seventeenth and in the opening of the eighteenth century had laid the scientific foundations of the microscopical method of investigation, hardly any substantial addition, beyond those awakening mere curiosity, had been made to the observations of those eminent investigators. At the beginning of the nineteenth century, Dutrochet, Mirbel, Saussure, and Knight had inaugurated a more searching investigation into anatomy and physiology. Link, Treviranus, and Rudolphi followed with still more elaborate and comprehensive researches, and paved the way to the discoveries early attained and rapidly accumulated by Ehrenberg's genius and industry. His master mind discerned the disconnected facts and details of his material in the light of uniformity and generalization. In lieu of the then prevailing belief in *generatio equivoca*, one of the first achievements of Ehrenberg was an account of a long series of investigations, at once strikingly acute, thorough, and convincing, of a large number of fungi, demonstrating that they, no less than the higher vegetable organisms, originated from seeds. He soon explored the cryptogamic flora of the environs of Berlin, and published a series of

important discoveries in his dissertation entitled "Silvæ mycologicæ berolinenses" (1818), and in other essays. To the former he prefixed the motto, which became, as it were, the key-note of all his later labors and works:

> Der Welten Kleines auch ist wunderbar und gross,
> Und aus dem Kleinen bauen sich die Welten.[1]

While still a student, the novelty and exactness of his observations and researches, and the high order of his deductions, at once established their author's reputation; and many of the eminent scholars and professors of the Prussian capital encouraged and aided the rising investigator, among them Lichtenstein, Alexander von Humboldt, Rudolphi, Link, Klug, Von Schlechtendal, Adelbert von Chamisso, Carl Ritter, Kunze, E. Mitscherlich, and others. After having passed the state medical examination, he was proposed for a professorship at the University of Königsberg, and also by the Berlin Academy of Sciences as a scientific *attaché* to an archæological expedition to the Nile countries, instituted by the Prussian General von Minutoli. He accepted the latter offer, together with his friend Dr. Hemprich, of Berlin. The expedition started from Alexandria in Egypt, in September, 1820, went through the Cyrenaica to the oasis of Jupiter Ammon, back to Cairo; in 1821 to Fajum, the pyramids of Sakhara, to Dongola in Nubia; in 1823 to the Sinai peninsula, to Syria, the Lebanon ranges, to Balbek and return by the way of Tripoli to Damietta. These expeditions were followed by others into Abyssinia, sailing down the Red Sea, stopping at and making trips to Tor, Djedda, Mecca, the islands of Gumfude, Ketumbul, Dalac, Farsan, etc. At Massauna the joint expedition came to an untimely end by the death of Dr. Hemprich in 1823. Ehrenberg then accomplished the plan of their mission alone.

To what hardships and dangers Ehrenberg was exposed for years while traveling through and exploring arid deserts, amid hostile tribes of marauding Arabs, during the prevalence of an epidemic of the plague, and unprovided with any of the comforts and conveniences of later expeditions, may be seen from the simple fact that the expedition lost seven of its members by death, and that of its scientific *attachés* Ehrenberg alone survived. He returned to Berlin in 1826, with magnificent collections of botanical, zoölogical, and geological specimens, embracing all departments of natural science, and an immense number of microscopical preparations until then unknown, and which remain for verification and ready inspection to this day. The extent and importance of these rare collections may be estimated by the mere statement that they included 46,000 botanical specimens, representing 3,000 species of plants; about 34,000 specimens from the animal kingdom, representing 4,000 species; while no less comprehensive were the

[1] The small too in the universe is wondrous and great,
And worlds are constituted out of that which is little.

geological and ethnographical collections, the geographical and meteorological observations, and other results of the expedition.

Considering such material mainly as requisite means for investigation and for comparative study, Ehrenberg now applied himself with unceasing zeal and diligence to his rich collections, assisted by eminent scholars and artists, for the illustration of microscopical objects. The results were published during the years 1828–1830, in a volume entitled "Scientific Travels through Northern Africa and Western Asia, by Ehrenberg and Hemprich," and in a series of elaborate, strictly scientific works, written in the Latin language, with more than eighty splendid illustrative plates, the principal ones being the following: "Symbolæ physicæ, seu icones et descriptiones mammalium" (1828), "Symbolæ physicæ avium" (1828), "Symbolæ physicæ insectorum" (1829–1834), "Symbolæ physicæ animalium evertebratorum sepositis insectis" (1829–1831).

The continuation of these consummate researches and labors was interrupted for about one year, when in 1829 Alexander von Humboldt, Ehrenberg, and Gustav Rose, on invitation of the Russian Government, undertook an expedition to the Ural and Altaï regions, with the special aim of exploring their mineral resources. After the return from this exploration, Ehrenberg entered upon the most fruitful epoch of his labors and career: he accepted a professorship at the Berlin University, but still continued his original researches with unceasing assiduity. His first publications had already attracted the attention of the learned throughout Europe, and secured for the young investigator a reputation among the remarkable array of *savants* then in Berlin. When that severe critic, Cuvier, in 1830, presented Ehrenberg's first publications to the "Institute of France," he accompanied them with these words: "Ces découvertes changent entièrement les idées et renversent surtout bien des systèmes, elles sont du nombre de celles qui font époque dans les sciences."

The continuous series of publications founded on and recording his discoveries and researches, had reference principally to such problems and objects as the phosphorescence of the ocean, corals, fossil as well as living deposits of minute organic remains in the strata of the earth's crust, the minute organic life in the atmosphere, the phenomena of blood rain and snow, dust-showers and the "Bleeding Host," which latter one, during the middle ages, was the cause of the most barbarous excesses of the Inquisition. All these investigations and works were followed by his splendid exploration, beginning with 1840, of the minute organic creation, and by the disclosure of the influence of that "realm of littleness" in the development of the present condition of the earth's crust, and on the whole organic life of nature.

In consummate generalizations he laid down the results of his lifelong, profound, and comprehensive observations and researches in the most famous of his many works, "Microgeology" (1854). Henceforth

governments, travelers, and scientists, from all parts of the globe, submitted specimens and problematic objects to the investigation or the verdict of the Berlin microscopist and *savant.* Deep-sea soundings, which began about this time, were especially fruitful in material for research; and the surprising result was brought to view that organic beings exist even at the greatest depth of the earth's submarine declivities, previously believed to be void of life.

Those who, in common with the writer, during Ehrenberg's most productive years, have witnessed and participated in the ardor and enthusiasm of the great and genial scholar and teacher, will ever remember with veneration the originality and conscientiousness of his methods of research, his wonderful skill, elegance, and acuteness in microscopical observation, and, above all, the lucid and graphic description of the master whose eyes undoubtedly had done more close and critical microscopical research than those of any contemporary. In him were fully and harmoniously blended the strictest sense of duty and truthfulness, the highest order of intellectual attainments, the exquisite taste of the accomplished classical scholar, and the charm of religious faith, genial disposition, and a generous heart.

Ehrenberg continued his work steadily and unfailingly to the end of his life, even when his eyesight had become impaired by protracted application, and when almost all of his famous contemporary co-laborers at the Berlin University had passed away.

In reviewing the discoveries, the works, and achievements of Ehrenberg, one is strongly impressed by their vast number and their high order in a domain at once so abstruse and so unlimited. In his hands, microscopical research first attained its proper application and a definite character, and revealed new fields of inquiry, afterward successfully trodden by others; his physiological and biological investigations paved the way for those discoveries which, in rapid succession, have been since effected in the structure and processes of the human body in health and disease, and which have shed much light upon the progress of every branch of the healing art. His researches and achievements contributed to every department of the physical sciences; the minute organic creation became, for the first time in our knowledge, a new link in the scale of animated beings, and its influence upon the formation of the strata of the earth's crust and their geological history was recognized. All the writings of Ehrenberg, the occasional orations and addresses delivered by him as Rector Magnificus of the University, as Permanent Secretary of the Berlin Academy of Sciences, etc., are masterpieces of learning, of exquisite style, replete with exalted ideas, and form enduring evidences of their illustrious author's eminence. His name will ever be honored as the father of modern microscopy.

How profoundly faith and rare modesty were congenial to his mind, will appear from the following brief passage from one of his latest rectoral orations: "Investigators and writers who, because at the limit of

their knowledge and powers, conclude that there is no soul, *ergo* no immortal life, may from their own point of view be quite right; but they are not on that account by any means to be accepted as representative men of science. The proper sentiment of the naturalist is this, that so far from pretending to inspiration or infallibility, he humbly recognizes the limitations inherent in his own intellectual powers, and imposed upon him and his time; while with all the faculties of his mind and soul, and with faith, he labors unbiased and assuredly, aiming at truth and confident of the usefulness of his life-work to his own or to subsequent generations, who sooner or later will recognize every true contribution to the stock of knowledge and to a purer and profounder insight into the wonders of the creation. The true investigator of nature should never divest himself of the idea that he is, as it were, a son in his Father's house and a co-worker, in his own humble sphere, with the great Ordainer of the universe."

The universal appreciation of Ehrenberg and his achievements found a spontaneous expression on the occasion of the celebration of the fiftieth anniversary of his doctorate in medicine, on November 5, 1868, when felicitations and honors poured in upon the veteran *savant* from all countries. The United States were represented in official congratulation by their Minister Plenipotentiary, Mr. George Bancroft, and in addresses from the American Association for the Advancement of Science, the American Medical Association, the American Pharmaceutical Association, and also in a poem by Dr. O. W. Holmes. These tributes were presented by Mr. Bancroft, who afterward had them all printed in a pamphlet.

Devoted and faithful to his life-work, he maintained his powers and his activity to the end. As stirring and brilliant as the day of his life had been, was its evening serene and hopeful; gently and without pain he passed away, on the 28th of June, 1876, in his eighty-second year.

His large and invaluable collections he bequeathed to the Museums of the University of Berlin.

CORRESPONDENCE.

SINGING MICE.

To the Editors of the Popular Science Monthly.

READING the article in your November number from "Nature" on "Singing Mice" recalls my experience with one of these interesting little animals: Some years since, while residing at Santa Fé, New Mexico, one of these vocal mice made its appearance in my house. The sounds were noticed some time before the animal was seen. As with Mr. Lee's mice, there was a canary-bird in the room, and for a time the notes coming from the wall were attributed to the canary. At last, however, the mouse would come out on the carpet seeking for crumbs, and there sing. The notes were almost identical with those of a canary. It would not trill so long, but in pitch and tone were identical —at least to an unmusical ear. The same filling and throbbing in the throat seen in a bird were also seen in the mouse while he sang The sound was not sibilant, but strictly canorous with the pitch of an ordinary canary. After this mouse had furnished entertainment for a month to myself and family, I found him so tame I could touch him, and that he was utterly blind. It was very touching to see the gentle little creature turn up its cloudy, sightless eyes to the candle when he was brought near to it on the floor of the dining-room. Small parties would assemble in the evening to hear this wonderful little vocalist without frightening him. He would come out on the carpet with all the confidence and *aplomb* of an old actor, and delight his hearers. I was afraid to keep him in confinement for fear he would die. Our cat was banished for the same reason, and we would not set any traps for fear he would be caught. Finally, we became so overrun that we had either to commence hostilities or abandon the house. We set a trap in a cupboard in the room, and alas! poor little singing Mus was the very first victim. I found, on examining the body, that he was exceedingly old—so old as to be blind, as I remarked—and his teeth were very long and yellow. The lower ones had grown up above the nostril. The existence of messmates or anything internal I did not verify. As for the theory of this accomplishment being the result of pregnancy, that was eliminated by the sex. I then had an idea that the sounds might have been produced by the air being forced through the long, overgrown gnawers, they acting as a sort of string. The animal was a true mouse. We have here a rat very little larger than a mouse, but it was not one of these. It was identical with the ordinary American mouse, and there was no peculiarity in color or length of ears, as remarked by Lee. This was the only one I ever had an opportunity of examining. The Mexicans, however, say they are not uncommon, and are superstitious about their appearance. My servants were greatly distressed and alarmed at the death of this one: a coincident ill fortune in the family was looked upon as having a plain and sufficient *raison d'être.*

LEWIS KENNON, A. M., M. D.

FORT BAYARD, NEW MEXICO, *January* 14, 1879.

DR. LARDNER AND TRANSATLANTIC STEAM-NAVIGATION.

To the Editors of the Popular Science Monthly.

IN your February number, Dr. Burns somewhat autocratically takes you to task for stating that Dr. Lardner had declared in some of his earlier lectures that steam-navigation across the Atlantic was "impracticable," and he quotes, from a very imperfect edition of Dr. Lardner's early lectures on the steam-engine, a foot-note by Professor Renwick, to show that it was the latter and not Dr. Lardner who at that time deemed the experiment impracticable.

As usual, you are correct in your statement, and Dr. Burns has fallen into a very material error, in the first place from not understanding the position of Dr. Lardner as implied by your remark in the December number of the journal, and from evidently not having read Dr. Lardner's later and fuller lectures on "The Prospects of Steam-Navigation," delivered in the principal cities of the United States during 1843 and 1844. The best edition of these lectures is the one published by Greeley and McElrath, of the "Tribune," in 1846, which edition was revised for publication by Dr. Lardner himself. I quote from his lecture on "The Prospects of Steam-Navigation," as found on page 269 of Volume I. His lecture begins with this statement of the facts obtaining then, as to ocean navigation, and his opinion as to its practicability:

"Ten years have now rolled away since the project was first announced to the world, to supersede the far-famed New York and Liverpool packet-ships, by a magnificent establishment of steam liners. . . . The

announcement was hailed with one general shout of acclamation. . . . There were some, however, who, being conversant with the actual condition of the art of steam-engineering as applied to navigation, . . . were enabled to estimate, calmly and dispassionately, the difficulties and drawbacks, as well as the advantages of the undertaking. . . . These persons entertained doubts, which clouded the brightness of their hopes, and warned the commercial world against the indulgence of too sanguine anticipations of the immediate and unqualified realization of the project. But the voice of remonstrance was drowned amid the loud shouts of public enthusiasm, excited by the promise of an immediate practical realization of a scheme so grand.

"The keel of the Great Western was laid, an assurance was given that the seasons would not twice run through their changes before she would be followed by a splendid line of vessels which should consign the 'packet-ships' to the care of the historian, as 'things that were.'

"The Great Western progressed and was launched, and the enterprise has now had a fair trial during ten years, a sufficiently long time, it is presumed, to test it. The packet-ships, however, have not been swept from the ocean; on the contrary, they have been improved in efficiency, increased in magnitude, and multiplied in number. Capital, instead of being drawn from them, allured by the prospective advantages of the steam liners, has only collected around them in augmented amount, obeying, as it always does, that irresistible attraction which profitable results invariably exercise in commerce. On the other hand, the steam project which was to prove their doom has made its flash, and disappeared, leaving the Great Western . . . alone in her glory . . . *to establish at once the abstract practicability of the scheme in a mechanical sense, and the utter inadequacy of its organization in a commercial sense.*"

This was the opinion of Dr. Lardner in 1846, nearly twenty years after the publication of the edition of his lectures quoted by Dr Burns, and more than ten years after ocean steam-navigation had become an established mechanical fact. The views entertained by Dr. Lardner at that time were very simular to those entertained by scientists to-day in regard to the problem of aërial navigation, mechanically practicable, but in the present conditions of inventions pertaining to it, so far as its commercial value is concerned, an impracticability; moreover, Dr. Lardner, in the lecture from which I quote, uses almost the same arguments quoted by Dr. Burns, from Professor Renwick's foot-note, viz., the large amount of fuel necessary for long ocean voyages, and the great expense attending its use, as compared with the cost of sailing vessels.

Dr. Lardner, however, lived to see ocean navigation by steam a success, commercially as well as mechanically, and to qualify many of the ideas and arguments advanced in his earlier lectures.

Very respectfully,

A. W. Erwin.

Sioux City, Iowa, *February* 3, 1879.

EDITOR'S TABLE.

MORE ROOM FOR THE SCIENCES.

It can not be kept too clearly in mind that the broad issue of modern educational reform is whether sciences or languages shall predominate as objects and instruments of culture. Shall physical nature, life, man, society, and the actual phenomena of experience, become the leading objects of study; or shall the acquisition of forms of speech, the accumulation of verbal symbols, and the discipline of grammar-grinding continue to hold their traditional ascendancy? No question now arises as to taking both of these modes of mental culture along together, for it is conceded on all hands that neither can be dispensed with, but the contest is as to which shall lead in a rivalry of widely different systems. The issue is, by which method shall the education of the future be characterized?

The languages are in possession, and of course have great advantages in the conflict from this fact. For the notion has grown up that a liberal knowledge of language *is* education, while nothing else is properly entitled to the name. Lingual studies, moreover, have the vast advantage that they are taken as the standards and measures of acquisition. Memorizing words, learning rules, construing and translating, make proficiency easily determinable; and when

scientific studies are introduced, as their results are not measurable by these old standards, it is inferred that they are not measurable at all, and are therefore unfitted to form the staple of systematic education.

But, although much is made of this difficulty, it is not serious. Science will create its own standards when it has had time and experience, and meantime its demands are for opportunity—room—facilities. An edifice can not be constructed until space is first granted for it to occupy; scientific education can not be organized until time and materials are yielded for the purpose. Old studies must be put out of the way, that new studies may take their place and the new education have a free course.

From this point of view we note and record with interest all indications that the old subjects which are now holding their place by the right of prescription and any pretexts that are available are yet compelled, by the tendencies of the times, to abandon their claims and surrender their ground. The advocates of the dead languages fight desperately to maintain their ancient precedence, but they are losing the battle. Even in England, where the whole framework of society is braced and bound by endowments which conserve the old and resist the new, and where the universities and public schools, rich and independent, combine against all modern encroachments, there are increasing indications that the old classical claims are regarded by their partisans as now untenable and must be given up. It is virtually if not avowedly conceded in high quarters that one or other of the dead languages must go, and in fact the classicists are already themselves at loggerheads as to which it shall be.

A step in the liberal direction was taken a few year ago, when the grammar-schools were remodeled by the Public Schools Commission by ceasing to make Greek an ordinary subject of instruction, and allowing the substitution for it of French or German. But now a still more significant step has been taken by several head-masters and other gentlemen interested in education, who have united to petition the authorities of Cambridge so to revise the scheme of university studies that Greek may be omitted if the student does not choose to learn it. At present it is a compulsory study, so that, though men entering the university "may be the equals of Airy and Adams in pure mathematics, of Tyndall and Huxley in natural science, of a Whewell and a Hamilton in moral science, they must be able to read a play of Euripidis and the Greek Testament, or Cambridge will not have them among its graduates."

The appearance of this memorial, signed by various weighty names, as might have been expected, has raised a controversial storm which has been chiefly vented through the columns of the London "Times." Mr. Oscar Browning led off with a letter full of sad forebodings, remarking, "To those who believe that national intelligence is the final cause of national greatness and prosperity, the proposal to surrender Greek will sound like the knell of disaster." The quiet way in which such a smattering of Greek as the students get at the universities is here taken as the equivalent of that national intelligence which leads to national greatness, shows us at all events that Mr. Browning believes in his Greek. He is, however, aware that there is another kind of knowledge with strong claims to attention, and thus refers to it: "There are many who look forward with satisfaction to the decay of classical education. In their eyes modern science, modern literature, modern interests, are fitted to give a wider and better education than was ever given by the contemplation of antiquity. The new learning which clamors on all sides for recognition, calls out their enthusiasm and zeal; the old learning

is discredited, as the subtilties of the schoolmen were discredited at the time of the Renaissance."

Mr. Browning has not much faith in this kind of knowledge for purposes of education, but, if it is bound to come and something must be given up, he will stick by his Greek, let who will suffer. He says: "If one of the two languages must go, let it be Latin. Greek is in every respect more valuable. As a language it is more beautiful, more rich, more flexible. Its literature is incomparably superior. The loss of Latin can be compensated by the languages derived from it. Nothing can supply the place of Greek. It is idle to suppose that if Greek were omitted from our regular school curriculum it would continue to be studied by the older boys."

Nothing certainly could be more idle, for the study is not adapted to modern general wants, and therefore has to be maintained by compulsion and its position maintained by an artificial coercive policy. Science, on the other hand, has grown up outside the schools, without endowments, and has been mainly developed by private enterprise because it is adapted to the present stage of progress of the human mind.

One of the "Times" correspondents thus replies to Browning's suggestion that Latin be sacrificed:

"The answer to Mr. Oscar Browning's question, Why should not Latin be thrown over, if one of the two classical languages must cease to be compulsory at the universities? is not far to seek. It is true that Greek is easier to learn, can be mastered thoroughly in less time, has an incomparably finer literature, and brings back times of greater interest than Latin; but these advantages are surely trifling when compared with the fact that Latin is the foundation of the languages which half Europe speaks and all Europe understands, and that it was a Latin-speaking people which formed the institutions, legal, social, ecclesiastical, and political, which we now maintain. I suspect that the genius of the English character is too Roman, or at least too anti-Hellenic, to gain as much from a moderate acquaintance with Greek culture as it has gained from a moderate acquaintance with the prominent Latin authors."

RESTRICTIVE TENDENCIES IN GERMANY.

The great German experiment in empire-making conducted in these modern days by the "man of blood and iron" brings with it a train of developments which would be startling if they were not so legitimate and natural. Bismarck has the reputation of being a man of action and a great practical administrator, but behind and deeper than all this he is a thinker and a *theorist*, and the final estimate of him will depend, not on the greatness of the transactions which he has directed, but upon the character of his opinions. He holds certain hypothetical views of human nature, society, and government, and upon these he acts: the question is, Will time vindicate their truth? He is now at the height of power, and is lauded as a bold, sagacious, far-seeing statesman: will the future disclose him as a purblind political quack, as ignorant of his age and of all conditions of national permanence in modern times as the brilliant French adventurer who ravaged Europe in the beginning of the present century? This we shall not undertake to decide, but it looks, at any rate, as if Bismarck were cutting out work for his successors which they will probably not be able to perform.

When recently Professor Virchow solemnly admonished the scientific men of Germany to beware how they exercised the liberty of scientific discussion, lest they provoke governmental interference and suppression, it was thought, outside of Germany, that he was hardly in earnest, and was merely girding at

the Darwinians for the sake of effect. Yet he appears to have spoken as if by instruction, for it seems the determined plan of the Imperial Government not to allow that measure of freedom in speech which has become the established policy in other leading countries.

Constitutional government in Prussia, however, is but a recent thing, having sprung up within a generation; while the new German Empire was constituted by the treaties made at Versailles in January, 1871, during the Franco-German war. Taking into account, therefore, the previous discipline of the people, and the coercive military character of German state policy, too much in the way of liberality is certainly not to be expected in a short time. But it is nevertheless interesting and instructive to see how things hang together, and how one thing involves and leads to another in a thoroughly arbitrary form of government.

The German Empire, made up by the recent amalgamation of twenty-six states, and containing about 43,000,000 people, sustains an army on a peace-footing of 1,283,791 soldiers, with 31,843 officers and upward of 300,000 horses. Military service is compulsory, and the army is sustained by conscription. The strengthening of the measures by which the military system is maintained is illustrated by the following paragraph which recently appeared in the newspapers: "Sixty young men having quitted the district of Thaun, Alsace, to avoid conscription, they have been sentenced, by default, to 1,200 marks fine, or 200 days imprisonment, and to the seizure of their property to that amount."

That the maintenance of such a vast army in time of peace by grinding taxation, and for purposes of despotic violence, should have engendered a profound spirit of revolt against the institutions and social order of the country, is not surprising. Socialism is but the correlative of a rampant imperialism—the shadow of Bismarck. Did the Chancellor expect that people with their eyes open would not observe, and in this age that they would not think and comment upon what they saw? At any rate, he resolved to stifle all expressions of Socialistic doctrine in the German Empire, and this he is no doubt at present quite able to do. The effects of the Socialist law are thus represented by a writer in Berlin: "The Prussian and German police in general is an admirable piece of machinery. It is almost as thorough and effective as the German army. It has never done its work better than in hunting down the Socialists. Up to December 22d, 144 clubs, 44 newspapers, and 157 books and pamphlets had been suppressed." The slaughter, or "pig-sticking," as the Chancellor is said to have grimly styled the game, has gone on briskly since that time; and the columns of the "Reichsanzeiger" give no sign that the authorities are becoming weary or merciful. The chief Socialist leaders have been turned out of Berlin, and it is difficult for them to find in Germany rest for the soles of their feet. Some are in prison. A few have emigrated in despair to America. In a few weeks perhaps no trace of the Socialist agitation will be discernible on the face of German society. But will the danger be gone when it is put out of sight? The Chancellor can not draw a cordon round the Fatherland and exclude the poisonous literature printed in London, Brussels, Verviers, or Geneva. The malady will not be cured because it is driven into the system. The seductiveness of Socialist opinions will not be a whit less than it is because the Government appears to dread them, and to have no confidence in the weapons of reason against the wild ideas that have taken hold of multitudes.

Believing in no half-way policy, Bismarck has now pushed his tactics a step further; the gagging of the people

is followed by a proposal to gag the German Parliament, the "Reichstag." Previous enactments having muzzled the press and silenced the voice of public meetings, a law was still required to fetter legislative debate whenever it threatened to take a range displeasing to the authority by which the country is really ruled. It is difficult for us to put the case in any other way than that Bismarck is ruling Germany by a policy which he knows will not bear free discussion.

That a Government founded upon arbitrary power, which plunders the country to sustain its armies, drags young men into its armies, drives children to school, and crushes the liberty of speech, should apply its restrictive methods also to trade, is not surprising. The enslavement of commerce belongs with the other tyrannical practices and enactments of the past; and the liberty of commerce can come only with the other liberties when the militant compulsory forms of society are outgrown or subordinated. That Bismarck should favor the hampering of German trade by increasing restrictive duties, as shown by a recent letter upon the subject, is no more surprising than his violations of the other natural rights of German citizens. Tariffs are the best means by which rapacious governments can get possession of the money of the people, and Bismarck must have money.

LITERARY NOTICES.

Origin, Progress, and Destiny of the English Language and Literature. By John A. Weisse, M. D. New York: J. W. Bouton. 1879. Pp. 800. Price, $5.

Two purposes are intended by the author of this work: first, to set forth a history of the English language and literature; and, second, to show the fitness of the English to become the universal language of civilized man. The Anglo-Saxon, the source from which English has sprung, was a composite language, consisting of three principal Gotho-Germanic elements, viz., the slightly variant dialects of the three northern nations which in the fifth century established themselves in Britain—the Jutes, the Saxons, and the Angles. The author's plan did not contemplate any set inquiry into the origin of these dialects; he has but little to say about their descent from one more ancient mother-language—the Aryan—he simply accepts them as a fact, and then proceeds to show how by the natural process of development, profoundly modified by the environment, they, or rather the one composite language, Anglo-Saxon, was compounded with other elements to form first the Franco-English (A. D. 1200 to 1600), and finally the English language as it now is. Dr. Weisse's method consists in setting before the reader specimens of the literature of the successive centuries from the invasion of the Angles, Saxons, and Jutes, down to the present time, and classifying the words according to the linguistic sources from which they come. The result shows the proportion of Anglo-Saxon, Latin, Greek, French, and other elements constituting the sum of the language at any given period. It shows, further, the changes undergone by the *form* of the language, if we may so designate its grammar, as distinguished from its *matter*, i. e., its vocabulary. Anglo-Saxon was a language possessing a variety of inflections to designate by the termination or by prefixes the diverse relations between words or their significates. Of these inflections English retains but few: a possessive (or genitive) case for nouns; an accusative (or dative) for some pronouns; the plural sign *s* final for nouns, and the final *s* in the third person singular of the verb; an imperfect (or aorist) tense of verbs; and perhaps some other traces. For the most part we now express by "prepositions," or by "auxiliary verbs," the relations expressed in Anglo-Saxon by inflections, or root modifications. Our author's specimens from the literature of the successive ages make all this very plain. Then the changes in the *matter* of the language, its invasion by foreign words, are exhibited. The first literary specimen in the volume is taken from Ethelbert's code of laws, which dates from the year 597. Here, as in the case of all the specimens

cited by the author, the linguistic source of each word is stated, and it thus appears that in Ethelbert's time out of 100 words not over six were other than pure Anglo-Saxon. Compare with this the constitution of English. Dr. Weisse finds that out of 100 words in the Bible 78 are Anglo-Saxon; in Samuel Johnson, 51. But of this side of the work we have written enough.

Dr. Weisse was an utter stranger to English up to his thirtieth year, and his estimate of the value of our language at that time was in direct ratio to his ignorance of it. Convinced of its inferiority to certain other languages, he commenced the researches of which this volume is the result, for the purpose of demonstrating that inferiority. His studies satisfied him that English "contains the cream and essence of its predecessors and contemporaries; that its grammar is simpler, and that its records and literature are more consecutive and complete, than those of any other tongue." He is not content to class English with the best languages of the globe; it surpasses them all: it is *the* best, the most flexible, the one language of all that have ever existed which is most suitable to become a universal language. But there exist some slight hindrances which Dr. Weisse labors to remove, and the principal one is that we do not "write as we pronounce or pronounce as we write." If our "orthography" were reformed and a few syntactical anomalies corrected, nothing could prevent the English from becoming universal. Already it is spoken by some 90,000,000 people, and English-speaking nations are the masters of a far larger area of the inhabited globe than are the nations using any other tongue.

The author does not confine himself very scrupulously to the programme indicated in his title, but is ever digressing to the right hand and to the left. His business is with the English language as it has been and as it is, but for page after page the reader might suppose that he was perusing a dogmatic treatise *de omnibus rebus.* Dr. Weisse himself is not unconscious of the irrelevancy of much that he has written, but he excuses it on the ground that his digressions serve to amuse the reader and make the perusal of the work a pleasure instead of an irksome task. For our part, when we wish to learn the truth about the supposititious visit of St. Paul to Britain, the history of Pelagius, or other topics, we prefer to get our information from the histories which deal with those subjects. Though not uninteresting, these digressions are a blemish, and should be omitted if the work reaches a second edition. The volume is a valuable contribution to the history of the English language, and we bespeak for it the earnest attention of our readers.

A Treatise on the Law of Property in Intellectual Productions in Great Britain and the United States. Embracing Copyright in Works of Literature and Art, and Playright in Dramatic and Musical Compositions. By Eaton S. Drone. Boston: Little, Brown & Co. 1879. 8vo, pp. 774. Price, $6.

The popular interest which the subject of the rights and wrongs of authors has recently awakened in England, France, and the United States, and the uncertainty and confusion into which the law of copyright has been allowed to drift, make a satisfactory treatise on this subject as welcome to men of letters as to the legal profession. The book before us is beyond comparison the most thorough and critical work on literary property yet published in England or this country, and, though an American publication, it is as complete an exposition of the English as of our own law. Our readers will remember that in his evidence before the English Copyright Commission, which we reprinted in the December "Monthly," Professor Huxley maintained that there was no distinction in principle between literary property and any other kind of property. Herbert Spencer and Professor Tyndall, who also testified before the Commission, were evidently of the same opinion. In a preliminary essay on "The Origin and Nature of Literary Property," Mr. Drone has gone to the bottom of this subject, and by an elaborate examination of all the principles, authorities, and arguments which bear on it, shows that literary property has the same general attributes and is governed by the same general principles that obtain in the case of all property. Hence the right of an author to his intellectual productions is no more a monopoly subject to the whims of the

Legislature than is the title of the owner to his lands or bonds. Until about a century ago this principle was recognized and acted on in England, where perpetual copyright in printed books was not denied till 1774, when the House of Lords, following the empty declamation of Lord Camden instead of the sound opinions of Lord Mansfield, Sir William Blackstone, and other learned jurists, decided, on an equal division of the judges, that authors had no rights in their published works excepting what Parliament might choose to give them. This decision has since controlled the law in England and the United States, but, as Mr. Drone forcibly maintains, it was "contrary not only to right and justice, but to the true purpose and meaning of the statute" (of Anne) "as determined by settled rules of construction."

The question whether the unlicensed abridgment of a copyrighted book is piratical, is one which is likely to be brought home to any author of an elaborate work. If the law on this point is governed by loose judicial *dicta* and doubtful precedents, honest authors have little reason to hope for protection against piracy. But Mr. Drone, following his plan of determining the law by governing principles, shows that the unauthorized abridgment of a copyrighted work is piratical. After a thorough discussion of the subject, he thus sums up the whole matter: "A genuine abridgment embodies the substantial results contained in the work abridged, and, if unauthorized, is damaging to the author of the original. The question of piracy is determined by the application of the established principle that no one without authority shall take a material part of another's work to the injury of the person entitled to protection. It is settled that piracy may be committed by taking a few pages from a copyrighted book; to hold that the substance of the whole may be lawfully appropriated, if published in the form of an abridgment, is as absurd as it is inconsistent and unjust." Under the head of blasphemous publications, he considers the question whether a work hostile to religion is entitled to copyright. Lord Eldon refused an injunction against the piratical publication of Sir William Lawrence's "Lectures on Physiology, Zoölogy, and the Natural History of Man," on the ground that the original contained passages which "impugned the doctrines of the immateriality and immortality of the soul." For similar reasons, the same judge refused to protect Byron's "Cain." Mr. Drone criticises these decisions as being unsound and illiberal, and maintains that even in England, where the law on this subject is more stringent than in the United States, there is no good reason why protection should be denied to publications in which the prevalent doctrines relating to religion are doubted or denied with moderation and sincerity.

Many other important and interesting questions are ably discussed in language which is singularly concise, clear, and free from legal verbiage. The work will doubtless take its place as the standard authority on the subject of which it treats.

FERNS IN THEIR HOMES AND OURS. By JOHN ROBINSON. S. E. Cassino, Publisher. Naturalists' Agency, Salem. Pp. 178. Price, $1.50. Illustrated.

THIS is the first American work devoted exclusively to the cultivation of ferns, and it is intended to serve as a guide to those in this country who are interested in the subject and would like to know how ferns may best be cultivated. The spirit of the book is well expressed on its last page in the following words: "The writer will not claim that the fern-mania, which may be traced from its beginning across the ocean to its recent development in this country, is a hobby superior to most others; but he does claim that, properly guided, it can be the means of stimulating pure and healthy exercise and study; and that, whether pursued in a scientific way or only as a pastime, it can in any event do no harm, but may be the cause of great and permanent good. If this little book shall in any way conduce to the love of the graceful plants of whose culture it treats, or aid any beginner in the study of the ferns, the writer will feel that another pleasure has been added to that which he has already experienced in its composition."

As an example of the ability of the author to carry out his purpose, we quote the following from Chapter V., entitled "How to collect Ferns for Cultivation." Premising that the desire to collect ferns is

a natural accompaniment of vacation-trips, the author says:

When we meet them in their full beauty they are in the most unfavorable state for transplanting, as, in the vigor of its growing condition in its natural home, a fern will endure little rough handling, and requires tender care to persuade it to grow in any other place. It would be better to wait till the season's activity is passed, which it is probable we can not do; or collect our ferns in the early spring, before the croziers unroll; but when the plants are in this condition, only an experienced botanizer knows what to look for and where to find it. Suppose, then, that in July or August we wish to obtain a small collection of our native ferns in their living state. The best way of transporting them is, of course, with their fronds uncrushed, in a box or basket of sufficient size. But this is not always practicable. It may be necessary to condense them into the smallest possible space. As we collect them the ferns can be kept in a bowl or basket till we are preparing for our journey home. When we gather them the roots should be carefully dug up, not wrenched from their surroundings; and, when we begin to get them ready for their travels, should not be very wet. Suffer the plants to remain without water a day or two before packing, only do not allow them to become exactly dry. Then we may shake off as much of the earth as will readily fall away, and, wrapping each fern with a bit of damp (not wet) moss, roll it up in a bit of paper large enough to hold all together, tying the parcel with a thread. The fronds should all project beyond the moss and paper, and only enough of them be left to insure a healthy start the next season—three or four on an ordinary and six on a very large plant. To remember how the ferns looked (for we are not yet supposed to know their names), it is a good plan to press a frond of each, and number it, tying a tag with the corresponding number to the specimen itself. When this is done, all the packages should be arranged with the fronds lying in the same direction, and a number of fresh fronds should be collected and tied around the fronds of the ferns to be carried home. Then the whole may be rolled up firmly into a bundle, covered with several thicknesses of stout manila paper and tied securely. The package is now ready to place in a trunk to deliver to the expressman or carry under the arm. Unless it is exposed to the sun, or in a very dry place, this bundle will not suffer in vitality or health for two or three weeks. At the journey's end the ferns must be carefully unwrapped and firmly planted in a good light soil, whether out of doors or in the fernery. At first nearly all the fronds will lie quite prostrate on the ground, but if they are frequently sprinkled on both sides and their roots kept only damp, the plants will establish themselves and reward the pains bestowed upon them by a fine healthy growth the next season.

The volume contains six colored illustrations of interesting species, and numerous plates illustrative of the growth and culture of ferns. A very tempting frontispiece shows the fern-corner of the writer's greenhouse. There is an important chapter concerning soils and pots for ferns, with pictures of pots of several different forms: one upon fern-cases, another with lists of ferns suitable for cultivation in tropical and temperate houses and in fern-cases. Fern-pests are also discussed, and pictures of nine of these creatures are given in plate 22. But further details are needless; the book teems with useful instruction from beginning to end.

Sanitary Examinations of Water, Air, and Food. A Handbook for the Medical Officer of Health. With Illustrations. By Cornelius B. Fox, M. D., M. R. C. P., London, Medical Officer of Health of East, Central, and South Essex; Fellow of the Chemical Society, etc., etc. Philadelphia: Lindsay & Blakiston, 1878. Price, $4.

This volume appears in response to a demand, by the scientific world, and especially of those engaged in the public-health service, for a third edition of the *brochure* on "Water Analysis." The author has rewritten nearly all he had before published upon the subject, and now offers the results of an increased and extended experience. He has also incorporated with his essay on "Water Analysis," sections on "Examinations of Air and Food." His aim is to furnish hints and suggestions, helpful to those who have not, like himself, "plodded for years through tortuous paths, at the sacrifice of much time and labor." In preparing the book, two objects were kept steadily in view: "1. To avoid a consideration of these three subjects, solely after the manner of an analyst, who mechanically deals with chemical operations and arithmetical calculations, but to treat them as a physician who studies them in connection with health and disease; 2. To render such details respecting examinations of water, air, and food, as fall within the province of the medical officer of health, so free from technicalities, and all cloudy and chaotic surroundings, as to enable any one, who possesses the average chemical knowledge of a physician, to teach himself, by the aid of this *vade mecum* of the health officer."

The following extracts will give a fair idea of the author's admirable directness of statement, and the valuable practical information he has been able to substitute for much of the technical detail that usually encumbers such a book:

An excess of aqueous vapor in the atmosphere has not only a depressing effect on the nervous system, but it interferes with the cutaneous and pulmonary exhalations. If the temperature is high (65° to 80° Fahr.), saturated air is sultry and offensive. If low (e. g., a Scotch mist of 36° Fahr.), its chilling influence penetrates all clothing. At least one half of the patients which apply for relief during the winter months to the physicians of the metropolitan and provincial hospitals of this country are afflicted with colds, coughs, and bronchial and rheumatic affections. The prevalence of these disorders at this season is, without a doubt, due partly to the coldness and partly to the excessive moisture of our very changeable climate. Above 80° Fahr., air of excessive humidity becomes injurious; and it has been doubted as to whether life can be prolonged in such air at a temperature between 90° and 100° Fahr.

The relation between such lung diseases as bronchitis and pneumonia and the unwholesome condition of the air of our dwellings has not been sufficiently recognized by the medical profession and the public. One of the most common causes of an attack of bronchitis is a sudden exposure of the bronchial mucous membrane to extreme conditions of air. A man who breathes for some hours the hot and dry vitiated air of an unventilated room is prone to be thus affected on passing out into cold, damp night air. If debilitated, from any cause, the inflammation may affect the substance of the lung, and the man will have pneumonia.

General Vaccination. By Elisha Harris, M. D. Cambridge: Riverside Press, 1877. Pp. 16.

In this paper, Dr. Harris presents his well-matured views on the laws, sanitary provisions, and methods best fitted for securing the benefits of general vaccination throughout the United States. The same author, in another paper, suggests plans for securing complete and authentic records of deaths and the causes of death in this country.

Constituents of Climate. By F. D. Lente, M. D. From the "Richmond and Louisville Medical Journal," 1878. Pp. 56.

The author of this pamphlet is a resident of Florida, and considers the "Constituents of Climate" with special reference to the climate of that State.

Democracy in Europe. By Sir Thomas Erskine May. 2 vols. New York: W. J. Widdleton, 1878. Pp. 495, 568. Price, $5.

The progress of democracy, that is, of popular power, in European states, is a fact that is regarded with widely different emotions—some persons seeing in it unmixed evil, while others expect from it the solution of all the problems which vex the student of political science. The event will in all probability confound the adherents of both of these extreme opinions, and it will be found, after the last barrier to popular self-government has been removed, that the human race will still pursue the even tenor of its way. But, however this may be, the work before us treats of a living question, and is sure to win the attention of the thinking public.

Our author investigates the causes to which the progress of democracy in Europe is to be ascribed; how far it has contributed to good government; what have been its dangers and mischiefs; and for his illustrations he goes to the East, to Greece, to Rome, the middle ages, the Italian republics, Switzerland, the Netherlands, France, and England. The work is a series of studies of democracy in the countries named, and the author is careful not to call it a "History of Democracy in Europe," which would be simply another expression for a "History of Europe."

Of the work in general it may be remarked that it gives evidence of diligent research and abundant learning; also that it is written in a highly philosophical spirit. No homage is here rendered to *forms* of government, nor is the power of mere statutes and constitutions regarded as paramount in shaping the destinies of man in society. On the contrary, Sir Erskine May expressly investigates the *social*, *moral*, and *physical* causes of freedom, shows how the development of popular power is a *natural law*, considers the influence upon society and freedom of local environment, as the sea, navigable rivers, etc.; the influence of race; and many other factors usually overlooked by the Dryasdusts.

Hence we are the more surprised at the fact that he himself has overlooked one of the most easily discernible factors in the development of democracy in Europe. If we are

to believe the testimony of many not unintelligent observers, a very evident tendency to "Americanization" is everywhere visible in European life, and naturally this tendency would be apparent first of all in political life. Even in the quiet of the German universities "Americanization" is an ever-present specter. Yet in these two volumes little or no reference is made to the United States. True, the author says of the American Revolution that "it was a prelude to revolution in Europe"; that it "stimulated the popular movement in England and in France." But that is all. With Sir Erskine May the post-Revolutionary history of the United States goes for nothing, apparently, in so far as European democracy is concerned. Surely this is a fatal oversight in our author, and one that can not be repaired without rewriting the entire work.

The Native Flowers and Ferns of the United States. By Thomas Meehan. Monthly Parts, each with Four Colored Plates. Boston: L. Prang & Co. 1878. 50 cents each.

We have before us Parts VI. to XII. inclusive, completing the first of the two volumes of this valuable work; and, though we have noticed it before, we take occasion on the completion of Vol. I. to again commend it to the favorable attention of our readers. The text is a familiar account of the different flowers and ferns. Their associations with human history, wherever such associations have existed, are pleasantly recounted; the medicinal and household uses of each species receive attention; the botanical characters are clearly stated; in short, the purely literary portion of the work is of the highest excellence. As for the plates, it can be said of them without exaggeration that they leave nothing to be desired, whether with respect to their artistic beauty or their fidelity to nature.

The Races of European Turkey. By Edson L. Clark. New York: Dodd, Mead & Co. 1878. Pp. 532. Price, $3.

The first of the three parts into which this work is divided contains a sketch of Byzantine history from the beginning of Justinian's reign down to the fall of Constantinople. The second gives an account of the modern Greeks and Albanians, their national characters, the state of religion and education among them, and their present condition and prospects. The third part is devoted to the Turkish Slavonians, the Wallachians, and the Gypsies, with sketches of the history of Servia, Bulgaria, and Montenegro.

Report of the Board of Regents of the Smithsonian Institution for 1877. Washington: Government Printing-Office. 1878. Pp. 500.

Among the most important papers contained in this report is one on "Color-Blindness in its Relation to Accidents by Rail and Sea," by Professor Holmgren, of the Upsal University. The author gives the history of color-blindness, and points out practical methods for discovering and determining defects of the sense of color. To this treatise is appended an article on "Color-Blindness" contributed to the "Princeton Review" more than thirty years ago by Professor Joseph Henry. There is a number of papers, by different authors, on American antiquities. Other essays in the report which are specially worthy of notice are: "Notes on the History and Climate of New Mexico," "Change of the Mexican Axolotl to an Amblystoma" (translated from the German), "Diminution of the Aqueous Vapor of the Atmosphere with Increase of Altitude" (translated from the French), together with several other short memoirs on meteorological subjects.

Bulletin of the United States Geological and Geographical Survey of the Territories. Vol. IV., No. 3, pp. 200; No. 4, pp. 140. 1878. Washington: Government Printing-Office.

The contents of No. 3 include notes on the birds of Dakota and Montana, by Dr. Elliott Coues; on fishes from the Rio Grande, by Dr. D. S. Jordan; on the North American *Pyralidæ*, by Professor A. R. Grote; paleontological papers, by Dr. C. A. White; notes on fossils found in a dark shale discovered at Independence, Iowa, by Professor S. Calvin; and a paper on the mineralogy of Nevada, by Dr. W. J. Hoffman. No. 4 comprises a memoir by S. H. Scudder on certain fossil insects; a report by Dr. E. Coues on the fishes of Dakota and Montana; a catalogue of plants of the same region, by

the same author; remarks by Dr. F. M. Endrich on some striking products of erosion in Colorado; a paper on the Laramie group of rocks, by Dr. C. A. White; and finally a synonymatic list of the American Sciuri, by J. A. Allen.

Our Revenue System and the Civil Service, by A. L. Earle; Suffrage in Cities, by S. Sterne; Protection and Revenue in 1877, by Professor W. G. Sumner; France and the United States; Free Trade, by R. Hawley. New York: Putnam's Sons. 1878. 25 cents each.

The titles of these publications sufficiently indicate their purpose—viz., to diffuse among the people information concerning the great economic questions of the time. The volumes constitute a series of "Economic Monographs," published under the auspices of the New York Free Trade Club.

The Strength of Materials, by W. Kent, M. E., pp. 140; Handbook of the Electro-Magnetic Telegraph, by A. E. Loring, Practical Telegrapher, pp. 98; Maximum Stresses in Framed Bridges, by Professor William Cain, C. E., pp. 192; Geographical Surveying: its Uses, Methods, and Results, by F. de Yeaux Carpenter, C. E., pp. 176; Transmission of Power by Compressed Air, by Robert Zahner, C. E., pp. 133. New York: Van Nostrand. 1878. Price, 50 cents each.

These latest volumes of Van Nostrand's series of brief treatises on subjects of practical science need no commendation. They are all written by men perfectly well versed in the subjects of which they treat, and the practical mechanician, electrician, surveyor, etc., will find in them precisely that kind and that measure of information which they most urgently need.

Zoölogy of the Vertebrate Animals. By Alexander Macalister, M. D. Pp. 146. Astronomy. By R. S. Ball, LL. D. New York: Holt & Co. 1878. Pp. 167. 60 cents each.

The volumes named above are the first two, we believe, of a series entitled "Handbooks for Students and General Readers." Wherever it may appear to be desirable, the works are revised with special reference to the United States. Thus the volume on the Vertebrates is "specially revised" by Professor A. S. Packard, Jr., and the Astronomy by Professor Simon Newcomb. The editors and publishers of the series appear to have spared no pains and no expense to make the several volumes as perfect expositions as may be under the circumstances of the various departments of knowledge of which they treat.

Total Abstinence. By Benjamin Ward Richardson, M. D., etc. London and New York: Macmillan. 1878. Pp. 119. 50 cents.

The advocates of "prohibition" and "total abstinence" will derive great encouragement from the perusal of this little pamphlet: it contains the strongest arguments that can be advanced on the physiological side in favor of their views. Readers who are neither prohibitionists nor total abstainers would do well also to examine the matured opinions on the "wine question" of so eminent an authority as Dr. Richardson.

PUBLICATIONS RECEIVED.

Journal of a Tour in Marocco and the Great Atlas. By J. D. Hooker, K. C. S. I., etc., and J. Ball, F. R. S. London and New York: Macmillan. 1878. Pp. 515. $6.50.

Lectures on Materia Medica. By Carroll Dunham, M. D. New York: Printed by Francis Hart & Co. 1878. For sale at homœopathic pharmacies. Vol. I., pp. 409; Vol. II., pp. 419.

Natural History of the Agricultural Ant of Texas. By H. C. McCook. With Plates. Published by the Author. Academy of Natural Sciences, Philadelphia. 1879. Pp. 310. $4.

Lecture Notes on Chemical Physiology and Pathology. By Victor C. Vaughan, M. D. Ann Arbor, Michigan: Ann Arbor Printing and Publishing Co. 1878. Pp. 315.

The Great Slighted Fortune. By J. D. Bell. New York: T. Y. Crowell. Pp. 462. $1.50.

New and Original Theories of the Great Physical Forces. By U. R. Rogers, M. D. Published by the Author. 1878. Pp. 108.

Paradoxical Philosophy: A Sequel to "The Unseen Universe." London and New York: Macmillan. 1878. Pp. 235. $1.75.

Harmony of Science and the Bible on the Nature of the Soul. By J. U. Kellogg, M. D. Pp. 224. 75 cents.

Diphtheria: its Causes, Prevention, and Proper Treatment. Same Author. Battle Creek, Michigan: "Review and Herald" Publishing Co. 1879. Pp. 64. 25 cents.

Wanderings in South America. By Charles Waterton. London and New York: Macmillan. 1879. Pp. 536. $6.50.

Demonology and Devil-Lore. By Moncure Daniel Conway. New York: Holt & Co. 1879. Vol. I., pp. 444; Vol. II., pp. 483.

Native Flowers and Ferns of the United States. By Thomas Meehan. Boston: Prang & Co. 1878. Parts 17, 18, 19, 20. 50 cents each.

Index Medicus: Monthly Classified Record of the Current Medical Literature of the World. New York: Leypoldt. Vol. I., No. 1. Pp. 72. $3 per year.

Relation of Adhesion to Horizontal Pressure in Mountain Dynamics. By H. F. Walling. With Plates. From "Proceedings of American Association." Pp. 20.

On the Crystallography of Calcite. By J. R. McD. Irby. Bonn: Charles George print. 1878. Pp. 72.

Annual Report of the Health Officer of the District of Columbia (1878). Washington: Government Printing-Office. Pp. 117.

The Aphididæ of the United States. By C. V. Riley and J. Monell. With Plates from Bulletin of the United States Geological and Geographical Survey of the Territories. Pp. 32.

Report of the State Board of Health of Colorado (1877). Denver: "Tribune" print. Pp. 161.

Dictionary of Music and Musicians. By George Grove. London and New York: Macmillan. 1879. Part V. $1.25.

Industrial Education. By Alexander Hogg. Galveston, Texas: "News" print. 1879. Pp. 52.

Aural Therapeutics. By S. Theobald, M. D. From "Maryland Medical Journal." Pp. 10.

A New Order of Extinct Reptiles. By Professor O. C. Marsh. With Plates. From "American Journal of Science and Art." Pp. 8.

Some Early Notices of the Indians of Ohio. By M. F. Force. Cincinnati: Clarke. 1879. Pp. 75. 50 cents.

The Applications of the Physical Forces. By Amédée Guillemin. Part I. London and New York: Macmillan. 1879. Pp. 48. 40 cents.

Inequality in Length of the Lower Limbs. By William Hunt, M. D. From "American Journal of Medical Sciences." Pp. 6.

Are Inebriates Automatons? By G. M. Beard, M. D. From "Quarterly Journal of Inebriety." Pp. 12.

Address and Memorial in Opposition to the Bill to amend Statutes relating to Patents. Cincinnati: "Times" print. 1879. Pp. 76.

Inscribed Stone of Grave Creek Mound. By M. C. Reid. From "American Antiquarian."

Address of Professor A. R. Grote, Vice-President Section B, American Association. Salem: printed at the Salem press. 1878.

Report on the Walnut Hill Asylum. Hartford, Connecticut: Press of Case, Lockwood & Brainard Co. 1878. Pp. 26.

Silica vs. Ammonia: Report of Dr. A. R. Ledoux. Raleigh, North Carolina: "Farmer & Mechanic" print. Pp. 23.

A Fable of the Spider and the Bees. Compiled by the National Defense Association. New York. 1879. Pp. 61.

Hampton Tracts: Health Laws of Moses; Duty of Teachers; Preventable Diseases; Who found Jamie? A Haunted House. New York: Putnams. 1879. 8 cents each.

The Antiquities and Platycnemism of the Mound Builders of Wisconsin. By J. M. De Hart, M. D. Pp. 15.

On the Illumination of Lines of Molecular Pressure. By W. Crookes, F. R. S. London. 1878. Pp. 11.

Objections to the Doctrine of the Resurrection of the Body. By a Physician who has seen an Angel. Philadelphia: Gross & Halloway print. Pp. 21.

Alcoholic Medication. By N. Newby, M. D. Spiceland, Indiana. 1877. Pp. 16.

Extent and Significance of the Wisconsin Kettle Moraine. By T. C. Chamberlin. From Transactions Wisconsin Academy of Sciences. Pp. 36.

Yellow Fever. By J. Livingston. New Orleans: Hyatt print. Pp. 16.

Congress and the North Pole. By Captain H. W. Howgate, United States Army. Kansas City, Missouri: "Review of Science and Industry" print. 1879. Pp. 43.

Spencer's Social Anatomy. By H. M. Simmons. From Transactions Wisconsin Academy of Science. Pp. 6.

Thoughts on our Conceptions of Physical Law. By Professor Francis E. Nipher. Kansas City, Missouri: "Review" print. Pp. 9.

POPULAR MISCELLANY.

Printing and the Perpetnity of Modern Civilizations.—The subjoined remarks on the influence of printing on the permanency of our modern civilizations are from the able address delivered in August last before the American Association for the Advancement of Science, by Professor A. R. Grote, Vice-President of Section B:

Those who have brought together the story of the ancient civilization of Greece have agreed with unanimity that the separation between the mass of the people and the intellectual portion became at length insurmountable, and finally led to national destruction. This makes for our own view, that it was to a defect or incompleteness in the machinery for the dissemination of knowledge that we must ascribe the dying out of the older states. An intellectual aristocracy was established in Greece, which, in order to maintain its superior position, and thus, from natural and selfish motives, endeavored to prevent the spreading of new facts, but it was assisted in this action by the limitations which an ignorance of the art of mechanically duplicating writing threw around it. Philosophers have explained the fall of Greece, by considering it as a necessary step in the progress of humanity and the perfection of a future bloom of knowledge. And so in one sense it may be; but still exactly where the defect lay, and where there is a positive advantage in the conditions of modern civilization, and wherein modern civilization more adequately protects the state, have sometimes escaped them. To understand this fully we must

come back to natural history, to anthropology, at last. A large class of persons with a certain bias persistently decry our modern civilization, and look for its more or less speedy evanishment, merely because Rome perished and Greece decayed. But nowhere in nature is there exact repetition, and to understand the new civilization we must remember that it rests on a larger average intelligence, brought directly about by the discovery of the art of printing. There is then a distinct reason, a scientific ground, for the opinion that our present civilization rests upon a surer basis than did those which preceded it, and this we may safely bring forward in the cause of truth. For science is in danger always of being regarded as the enemy of the state, because it tends constantly to modify existing ideas. But if we can show the necessity for a constant modification of our ideas, arising out of our own constitution, then it may be seen to be unreasonable to defame those who follow the search for truth. And it being undoubtedly true, as Locke says, that, of all the men we meet with, nine out of ten are what they are, good or evil, useful or not, by their education, we can see how wide-reaching the effect of our improved basis of civilization must be upon us as a people, and how important it is to understand the real direction in which it works.

The Causes of Ocean-Currents.—An important contribution to the theory of ocean-currents is made by Professor Zöppritz, of the University of Giessen, who aims to show that these currents are produced by the impulsion of the winds. As Mr. Croll observes, in bringing Zöppritz's paper under the notice of English readers in "Nature," one of the main objections urged against this theory is that the winds can produce only a surface movement, while many of the ocean-currents extend to great depths. The reply to this objection is, that if the surface waters be impelled forward with a constant velocity by the wind or any other cause, they will drag along with themselves, though with a velocity somewhat less, the layer immediately below themselves. This second stratum now exerts the same influence on a third adjoining stratum, and sets it in motion in the same direction. The third stratum, in like manner, draws with itself a fourth, and so on. The propagation of this velocity is only bounded by the limits of the fluid itself. If these limits consist of a solid plane parallel to the strata, then the propagation of the velocity will cease only at that point, i. e., between the last liquid stratum and the first solid stratum. Among the results found, the author lays particular emphasis on two: "In the first place, the steady motion arising in the interior of an unlimited stratum of water from an unvarying surface velocity makes itself felt with linearly decreasing velocity down to the bottom. Hitherto the view frequently expressed was, that the influence of surface currents reached only to very moderate depths. Secondly, it was found that all variations according to time, whether periodic or aperiodic, of the forces acting on the surface, propagate themselves downward with extraordinary slowness, the periodic in very quickly decreasing amount. Taking both statements together, it follows that the movement of the chief part of the stratum of water exposed to periodically varying surface forces is determined by the mean velocity of the surface, and that the periodic variations are observable only in a comparatively thin surface stratum."

Population-Density and Rates of Mortality.—Some curious and interesting results are developed by Dr. Farr, F. R. S., from a study of the rate of mortality in connection with statistics of population-density. He finds that the rate of mortality increases as density of population increases, and this he proves by arranging the 619 districts of England and Wales in groups according to the rates of mortality, and showing that all the groups follow this law. Thus in the ten years 1861–'70, at one end of the scale the deaths per 1,000 of population are 15, 16, and 17; at the other end, 31, 33, and 39. The acres *per capita* in the corresponding districts are 12, 4, and 3, and 1·01, ·05, 1·01. The intermediate rates of mortality are 18, 19, 20, 21, 22, 23, 24, and 25, while the acres *per capita* are 4, 3·3, 2·9, 2·1, 1·1, ·05, and ·02. Now, excluding the London districts, about which there is some difficulty, we have 7 groups of districts where the mortality ranges thus: 17, 19, 22, 25, 28,

32, and 39. In the same districts the number of persons to a square mile is 166, 186, 379, 1,718, 4,499, 12,351, and 63,823. Thus, in Liverpool, the densest and the unhealthiest district in England, there were 63,823 to an acre; of whom 39 per 1,000 died annually. This series of facts may be put in a different way: The nearer people live to each other the shorter their lives are. Thus the proximity of people in 53 districts is 147 yards, the mean duration of life is 51 years; in 345 districts the proximity is 139 yards, and the mean duration of life is 45 years; in 137 districts the proximity is 97 yards, and the mean duration of life is 40 years; in 47 districts the proximity is 46 yards, and the mean duration of life is 35 years; in 9 districts the proximity is 28 yards, the mean duration of life is 32 years. In Manchester district the proximity is 17 yards, and the mean duration of life is 29 years; in Liverpool district the proximity is 7 yards, and the mean duration of life is 26 years. This is a determined law, and, the duration of life being given in one set of conditions, the duration of life in another set of conditions is determined from the proximities.

An Interesting Collection of South American Fossils.—Prof. Cope bought the collection of fossil bones from the Argentine Confederation which were brought to show at the Paris Exposition. Several countries are said to have wanted them. They will be of value in this country, because the chief portion of them are not to be found anywhere in the United States. They come from Patagonia, and the collection includes about one hundred and fifty specimens of animals. There are nineteen skeletons, chiefly of large animals, almost completely whole, among which are armadilloes and sloths. One of the armadilloes has a curious tail which increases in size toward the end, at which point it takes an oval shape and is from a foot to eighteen inches wide. Unlike that of all other armadilloes, it is without joints, except that at the base. It is supposed to have been a fighting weapon. Another rare specimen is a sabre-toothed tiger, of which there is only one other known specimen in the world. The size of the sloth skeletons varies from that of a small black bear to the largest elephant. The sabre-toothed tiger and the club-tailed armadillo are supposed to have been monarchs of the forests in their day. It has not yet been determined to what institution of science the collection is to be presented.

Artificial Diamonds.—In examining the papers of their deceased father, J. N. Gaunal, Messrs. A. and F. Gaunal found one which purported to be a copy of a memoir presented by him to the Paris Academy of Sciences in 1828, and which gave an account of a process for the artificial production of diamonds. The Academy simply buried the communication in its archives, and never mentioned it in any way. The substance of this document is now published in "Le Monde de Science et de l'Industrie," from which we take the following particulars: Equal weights of carbon sulphide and of phosphorus, both as pure as possible, are put in a flask, and a little water added which floats on the top and prevents the sulphide from turning to vapor and from taking fire. The whole having been placed in some situation where it will not be disturbed, the sulphur of the sulphides combines with the phosphorus and releases the carbon, which falls to the bottom and assumes a crystalline form. This result takes place slowly, and not till after the lapse of six months was M. Gaunal able to obtain diamonds the size of a grain of millet-seed. As for the purity of these small diamonds it was proved by the strictest tests, and that not only by M. Gaunal but also by others. The experiment was repeated several times in the course of many years by M. Gaunal, and always with the same result. The artificial diamonds consist of pure carbon in dodecahedral crystals, and they scratch steel like the natural diamond.

Protection of Iron Surfaces from Rust.—We have already briefly described Professor Barff's method of rendering the surface of iron unoxidizable, yet, by way of introducing some remarks on the results of the process published in the "Lancet," we may repeat that it consists merely in subjecting the iron to the action of superheated steam—steam having a temperature of 1500° Fahr. This steam is generated in an upright boiler, and is then conducted through

the "superheater," which imparts to it the necessary temperature. The iron articles to be acted on are placed in a chamber built of fire-clay, and the steam being admitted to it a coating of magnetic, or black, oxide of iron is produced on the surface. And now for the result. The article has a dull-black appearance, and is susceptible of a high degree of polish. The surface coating is absolutely adherent, and is so hard that it is not removable by ordinary methods, for instance, an iron rasp has no effect on it; and the same is to be said of all the agents which under ordinary conditions oxidize iron. Salt or fresh water, vegetable acids, and even the London atmosphere, are unable to produce the slightest tarnish. Iron vessels which have contained water for weeks are entirely free from rust. Iron piping and ornamental castings, which have for months lain among the wet leaves in the garden outside Professor Barff's laboratory, are unchanged. The cost of the process is trifling, less than that of "galvanizing." The sanitary and domestic uses of iron thus prepared are numerous, as for water-pipes and cisterns and for cooking apparatus.

Plants and Atmospheric Humidity.—Two questions of considerable interest, viz., that of the effect of living plants on the atmosphere of houses and that of the relations between forests and atmospheric humidity, appear to have no little light thrown upon them by the ingenious researches of Dr. J. M. Anders, published in the "American Naturalist." We can not state with any degree of fullness the author's experiments to determine the amount of vapor transpired by plants in proportion to the area of their leaf surface. Suffice it to say that according to these experiments the "Washington elm," at Cambridge, Massachusetts, with its 200,000 square feet of leaf surface, would transpire seven and three quarter tons of watery vapor in twelve diurnal hours of clear weather. Carrying the calculation further, a grove consisting of 500 trees, each with a leaf surface equal to that of the elm mentioned, would return to the atmosphere 3,875 tons of aqueous vapor in twelve hours. In-doors, transpiration is during the day only about one half as active as in the open air, but at night it is about equal in the two situations: hence the transpiration of a plant in-doors is more than one half as much in twenty-four hours as it would be outside. It follows that growing plants increase the humidity of the atmosphere in a closed room. This point is very important where rooms are heated by hot-air furnaces. In such apartments the air is drier than in apartments heated by a stove or an open fireplace. In a dry atmosphere of the temperature of 65° to 68° Fahr. a great demand is made upon the system to supply the air with moisture, the skin and pulmonary mucous membrane are dried, and a condition is induced which is expressed in irritability of the nervous system, paleness and susceptibility of the skin to cold, liability to pulmonary diseases, and, in short, deterioration of all the functions. Now, if the presence of a certain number of thrifty plants in an occupied apartment, warmed by dry air, would have the effect of raising the proportion of aqueous vapor, it is clear that plants in rooms heated by a hot-air furnace would, in an hygienic point of view, be of very decided value, since they may become the means of obviating very distressing symptoms, or even disease itself. As for the question of the relation of forest-growth to atmospheric humidity and consequently to rainfall, such relation would appear to be clearly established by the author's researches.

Source of Organic Matter in Igneous Rocks.—Associated with the sheet of trap-rock which forms the First Newark Mountain, New Jersey, there occurs near Plainfield an amygdaloid trap passing into a metamorphosed shale. Many of the cavities in the amygdaloid rock are filled with a jet-black carbonaceous mineral, closely resembling the "albertite" of New Brunswick. Above the amygdaloid is a metamorphosed shale, traversed by seams and fissures, which are frequently filled with the same albertite-like mineral. Finally, resting on these metamorphosed beds are slates, shales, and sandstones, which contain fossil fishes and an abundance of obscure vegetal remains. From this state of facts Mr. J. C. Russell ("American Journal of Science" for August) infers that the organic bodies in the

uppermost strata furnished by their decomposition the carbonaceous material in the associated rocks, the heat derived from the slowly-cooling injected rocks playing an important part in this process. Similar deposits of carbonaceous mineral in igneous rocks are found in other localities, as at Cape Gaspé, and in the lava of Mount Etna, though in these cases it occurs in the less concentrated form of mineral oil. But Mr. Russell sees in these different forces only different stages of one and the same process. "If," he writes, "the cavities of a rock were filled with petroleum by infiltration, and evaporation slowly removed the more volatile portions, and oxidation took place to some extent, the result would be the formation of a deposit of solid hydrocarbon in the cavities. A similar process sometimes occurs with bottled samples of petroleum, by which the interior of the bottle is left coated with a solid carbonaceous layer. In the rocks, if a fresh supply of oil were furnished from time to time by infiltration, the cavities would eventually become completely filled with the solid carbonaceous residue. A vesicular lava might in this manner be changed to an amygdaloid, the cavities of which would be filled with solid hydrocarbons instead of quartz, zeolites, etc. Such, it appears to us, must have been the history of the Triassic amygdaloid we have described, the cavities of which must at one time have been filled with mineral oil. This is but an epitome of what took place on a grand scale at the great fissure, over 1,400 feet deep, in New Brunswick, which was filled with albertite, and in the case of the Grahamite in West Virginia, which also occupies an immense fissure."

Whence came the Arctic Mammoth?—Were the mammoths whose remains are found in the north of Siberia native in that region, or were they carried thither by rivers from a more genial climate? If the latter supposition were correct, we should find the remains only in the vicinity of the great watercourses, while, in fact, they occur in localities distant from the beds of streams. But here fresh difficulties face us, for, though the mammoth was covered with a thick coat of long hair, how could it live in a region where the temperature in January is as low as 65° Fahr., where the summer lasts only three or four months, and where the vegetation is exceedingly scanty? The supposition is plainly inadmissible, and hence either we must believe these remains to have been transported hither, or else that in early times the climate of Siberia was much less severe than it is at present. Nor is this a baseless theory, for, as Mr. U. H. Howorth observes, the plants found in the fissures of the rhinoceros-teeth (contemporary with the mammoth) are those which now live in southern Siberia. The plant-remains associated with the mammoth (not floated from a distance, but of the locality) show the same thing, the species being larch, birch, and other trees of good size. Other evidences of the existence of a higher mean temperature in Siberia at the time of the mammoth are found in the fresh-water and land shells associated with the remains, but now extinct in northern Siberia. As for the manner of the mammoth's extinction, Mr. Howorth believes it to have been sudden. The remains must have been preserved soon after death. They were destroyed by a flood due to some sudden convulsion, which also changed the climate.

Civilization and Teeth.—From the study of 1,249 skulls, of which 844 represent modern highly civilized races, and 277 modern inferior races, while the remaining 128 belonged to Romans, Etruscans, Phœnicians, and other nations of antiquity, Professor Mantegazza reaches conclusions which go to confirm a remark made by Mr. Darwin in "The Descent of Man." "It appears," writes Darwin, "as if the posterior molar or wisdom teeth were tending to become rudimentary in the more civilized races of man." Professor Mantegazza finds that the wisdom-teeth are more frequently absent in the superior than in the inferior types, the exact proportion being 42·42 per cent. in skulls of the higher races against 19·86 in the lower. But atrophy of the third molar tooth occurs less frequently in the higher than in the lower races, viz., in 10·90 per cent. of the former, and in 20·58 per cent. of the latter. In the lower races the abnormal cases are practically equal to the normal, while in the higher they are much

more numerous, the proportion being 62·91 per cent. to 37·09 per cent. Mantegazza is inclined to suppose that at a period more or less remote the third molar will disappear from the human jaw.

A New Plant.—A botanical discovery of considerable interest is announced in a letter, written by Dr. Beccari, from Sumatra. It is a gigantic aroid, which can only be compared with the Godwinia discovered by Seewann in Nicaragua. Dr. Beccari is as yet unable to determine the genus, but he believes it to be a *Conophallus*. The tuber of one plant was 1·40 metre in circumference, and two men were hardly able to carry it. From the tuber, as in the genus *Amorphophallus*, only one leaf is produced, which in form and segmentation does not differ much from that genus. But the dimensions are very different indeed. The stalk at the base in one instance was 90 centimetres in girth, was slightly less at the apex, and reached the height of 3·5 metres; its surface was smooth, of a green color, with numerous small, white dots. The three branches into which it was divided at the top were each as large as a man's thigh, and were divided several times, forming altogether a frond not less than 3·1 metres long. The whole leaf covered an area of 15 metres circumference. The spadix of a plant found in fruit had the stalk-dimensions just given; the fruit-bearing portion was cylindrical, 75 centimetres in girth, 50 centimetres long, and was densely covered with olive-shaped fruit 35 to 40 millimetres long, and 35 millimetres in diameter, of a bright-red color, each containing two seeds.

Advantages of Oral Teaching.—It would not be easy to compress within equal space a greater amount of practical common sense than we find in a recent communication entitled "Our Schools," printed in "The Examiner." "I believe," writes the author, "that one of the great stumbling-blocks to boys is want of oral teaching, in a popular style, particularly among little boys. It is a notorious fact that the grown-up world generally learns geography and history by means of newspapers and reading accounts of current events with the aid of the maps which are published from time to time for the purpose, and, if boys were taught in the same popular manner at the commencement of their education, it would do lasting good. We must all remember the dreary toil of mastering geography by learning a quantity of details out of a book about the number of inhabitants, names of rivers, the trade, the religion, and manners and customs of any country, without any means of impressing facts on the mind, while history becomes a positive treadmill when left to a boy's private reading. When the Prince of Wales went to India, if any one with an attractive manner of talking had taken a series of cartoons simply showing the rivers, the principal cities and mountain ranges, and some of the pictures published in the illustrated papers, he could, by arousing deep interest, have made the way easy for acquiring a fuller, more complete knowledge. The same mode of teaching would apply to the late European wars, the Indian famine, or any other great national event or calamity. We do this kind of thing in business matters every day of our lives in committees, on trials, and in all important transactions. It should be the same with boys; they should be interested in their subject before being set to master its drier details, which would, by this very introduction, lose much of their dryness."

Retentive Memories.—A number of instances of great retentiveness and accuracy of memory are recorded by a writer in "Chambers's Journal." Among the names mentioned is that of Dr. Robert Chambers, whose power of memory was very extraordinary. For example, on a certain occasion he was heard to say, "This day forty-seven years ago, at twenty minutes past two o'clock, I was passing" such a number of such a street, and met such and such a one. The author finds in Sir Walter Scott and in Charles Dickens a like accuracy of memory, and to this attributes no small share of their success as story-writers. Then a case is cited from one of Dr. Carpenter's writings of a clergyman who, on visiting Pevensey Castle, felt convinced he must have seen it before, and that when he did there were donkeys under the gateway, and some people on top of it. On inquiry he ascertained that he had been there with a picnic party, who made the excursion on donkeys, when

he was only about eighteen months old. Sometimes the whole history of a lifetime will be flashed before the mind as in an instantaneous picture. That this occurs sometimes when death, or peril of death, is imminent, is quite certain. It may be that this occurs very frequently before actual death; but this we cannot know, as all the instances of which we have accounts are those in which a man has described his sensations after having been saved from dying —especially from drowning. "When all hope of being saved is gone," says the author, "and the very struggle with the water is now made without conscious effort, it would seem that, without being prompted by the will, the memory suddenly grasps at once the deeds of the life that now appears about to close, and at the same time —and this is the most singular fact of the phenomenon—recognizes the usual rectitude or wrong of each act [?]. There is," he continues, "a case of this kind recorded of an English naval officer, who thus remembered the events of his life at the moment when he was struggling hopelessly in the wake of the ship from which he had fallen; and he confessed that he had been especially struck by the sudden coming into his thoughts of a schoolboy lie that he had long forgotten."

Economic Statistics of the World.—A general review of the economic statistics of the world in 1877 is published by Professor Neumann Spallart, of Vienna; from it we take the following statements:

Railways.—In the last three decades the network of European railways has risen from 9,000 kilometres (5,580 miles) in 1847 to 154,200 kilometres[1] (95,604 miles) in 1877. Of these 154,200 kilometres 27,500 are in Great Britain and Ireland; 24,800 in Austro-Hungary; 23,400 in France; 18,000 in Russia; 30,000 in Germany. The remainder is distributed among the smaller states. According to these figures Europe has 150 kilometres of railway for each thousand square kilometres and 4·8 kilometres per 10,000 inhabitants. These ratios are exceeded in Belgium, Great Britain and Ireland, Switzerland, the Netherlands, etc.

[1] One kilometre is about ⅝ of a mile.

America.—In 1830 the United States had 42 kilometres of railway; now they have 128,000 kilometres (79,360 miles), or 133 kilometres for every 1,000 square kilometres of surface, and 28 kilometres per 10,000 inhabitants. In the remainder of this continent there are 17,000 kilometres of railway, of which Canada has 7,000.

In India and Ceylon there are 11,000 kilometres, or 46 kilometres per 1,000 square kilometres of area and ½ kilometre per 10,000 inhabitants. In Africa there are 2,800 kilometres, whereof 1,800 belong to Egypt. Australia and New Zealand possess 4,000 kilometres of railway.

On all these railways are employed 62,000 locomotive-engines, 112,000 passenger-carriages, and 1,500,000 freight-cars; they annually carry 1,150,000,000 passengers, and 16,000,000,000 quarters of freight.

Marine.—The merchant marine of Europe embraces in all 7,400 ocean steamships with a tonnage of 3,000,000 tons, of which totals the United Kingdom contributes 5,200 steamships and over 2,000,000,000 tons of freight.

Telegraphs.—At the beginning of 1877 Europe had 351,000 kilometres of telegraph lines, whereof 65,000 belonged to Russia, 54,000 to France, 48,000 to Germany, 40,000 to the United Kingdom. America had then 183,000 kilometres. The dispatches sent over European lines numbered 82,000,000 in 1876; those sent over American lines amounted to 23,000,000. Asia and Australia have each 38,000 to 39,000 kilometres, transmitting 2,500,000 dispatches. In Africa there are only 15,000 kilometres, almost exclusively in Egypt, Algiers, and Tunis, and the number of dispatches sent is 1,200,000. There are 560 submarine cables, representing a total length of 65,000 nautical miles.

Postal Service.—The postal service now extends to the uttermost bounds of civilization, embracing the whole globe, from Hammersfest to New Zealand.

In Europe over 3,000,000,000 letters and postal-cards are carried yearly. In this total the United Kingdom is represented by over 1,000,000,000; Germany by 700,000,000; France by 366,000,000; Austro-Hungary by 300,000,000; Italy by 120,000,000. This would give for England 33 letters per

head of the population; for Switzerland, 24; Germany 15; France 10. Turkey figures for only 0·2 of a letter *per capita*. In America the number of letters and postal-cards carried was 700,000,000; in Asia, 150,000,000; in Australia, 50,000,000; in Africa, 25,000,000.

Gas-Stoves and the Products of Combustion.—City people are wont to express their surprise at the stupidity of the countryman who extinguishes a gaslight by blowing it out, and then sleeps in the same room. Yet the same acute city people will set up a gas cooking-stove, and will never think of the necessity of carrying away the products of combustion. Plainly, in view of the prospective large employment of carburetted hydrogen gas as a domestic fuel, it behooves the sanitarian to emphasize the necessity of proper regard for sanitary requirements. The public will have to be instructed in the simplest elements of science, and drilled to heed the plainest teachings of every-day experience, or else the general introduction of gas as a fuel will at first occasion a fearful amount of mortality. The observations of the editor of the "Lancet," in a house in the "West End" of London—the fashionable quarter of that metropolis—might be repeated any day in the "best quarter" of our American cities. The editor of the "Lancet" visited the kitchen of the house in question, having been asked to give an opinion as to the wholesomeness or otherwise of the cooking arrangements. He found a gas hot-plate with five circles of burners, each circle having 12 or 15 jets, so that when the hot-plate was fully heated 60 or 80 jets were in active combustion. Each jet produced about two cubic feet of carbonic acid per hour, a total of 120 to 160 cubic feet, in addition to sulphurous acid. No chimney was provided for the escape of the gas, and the very intelligent inmates of the house could not understand why the cook looked so pale and ill; as for the cook herself, though she often felt "giddy and fit to fall upon the floor," she never suspected the gas-stove! Now, since each of the gas-jets had an effect equal to the respiration of one human being, it is evident that the population of that kitchen practically amounted at certain times to sixty or eighty persons; and the exhalations from this "black hole" had no way of escape except through the kitchen door and into the house. This instance of the stupidity of "intelligent" people is so typical that it deserves to become "classic."

Effects of a Diet of Shingle-Nails.—The cows of a large dairy-farm in Hungary having been all simultaneously seized with disease, the symptoms being high fever, difficult respiration, and inflation of the body, it was determined to slaughter two of them and to make an examination of the bodies. The organs of the chest appeared perfectly normal. On opening the stomach its contents were found partly fluid and partly of pappy consistence, and among this matter were discovered a number of shingle-nails of various lengths, some of them free, and others partially imbedded in the walls of the stomach. Renewed investigation cleared up the mystery as to how these nails got there. About a year before, a shed on the estate caught fire, and the shingles of the roof were torn off, nails and all, in the attempt to put out the flames. In the winter the damaged materials were burned in the farm-buildings as fire-wood, the ashes subsequently strewed upon a clover-field, and the nails contained in the latter unfortunately were raked up with the hay crop obtained from it in the following summer. Every cow upon the farm had to be slaughtered, and in every case nails were found in the second stomach.

The Electric Light as a Source of Nitric Acid.—It is known that, when combustion takes place at high temperatures, small quantities of the nitrogen and oxygen of atmospheric air combine, forming several oxides of nitrogen, many of which are strong, corrosive acids. This is the case when electric sparks are passed through air, also during combustion in air of hydrogen. It therefore appears probable that, as the temperature of the electric arc is undoubtedly very high, nitric acid, or some other oxide of nitrogen, might be produced by the electric light. This subject has been investigated experimentally by Mr. T. Wills, with results strongly confirmatory of this theo-

retical inference. The first experiment was rather surprising. A glass cylinder placed over an electric lamp (Foucault's regulator) for two minutes, and afterward examined, was seen to contain a perceptible amount of red fumes, due to peroxide of nitrogen (N_2O_4). The air surrounding the lamp was next drawn through a solution of potash, and the amount of nitric acid estimated; this gave ten to twelve grains of nitric acid produced per hour (it may eventually prove to be more, the difficulty being to collect the whole of it). The next step in the research will be to examine the various forms of electric light, with a view to determine the amount of nitric acid produced by each.

In an Ants' Nest.—The columns of the Popular Miscellany from month to month give evidence of the interest with which naturalists study the ways of ants. Indeed, the life-history of that interesting insect seems to be full of surprises for the persevering observer. Here is an account of a nest of *Formica nigra*, in which a number of Termites were kept as slaves. While entomologizing in Portugal in 1877, in the neighborhood of Cintra, Mr. Henry O. Forbes found a nest of *F. nigra* under a stone. On turning the stone over, he observed great consternation in the community, evidently caused by the fear lest a colony of *Termes lucifugus*, which the Formicas had enslaved, should escape. The Nigras instantly began seizing the Termites, driving them underground by the nearest orifices, in the mean time wrenching and pulling off their wings. In the nest there was also a large number of Termite larvæ, and the great object of the Nigras seemed to be to get these underground as speedily as possible. The ants fell on them with fierce impetuosity, seizing them anyhow and anywhere, dragging them against the most strenuous opposition into the nearest apertures of the underground home. Very often this opposition resulted in a long and savage fight, in which the larvæ were badly wounded, being deprived sometimes of their antennæ, sometimes of half their jaws, and not seldom killed outright. Occasionally, however, the larvæ were victorious, beating off the Formicas. The observer saw at the end of a long fight one larva drawn by its antennæ, while it strenuously held on to a small ball of earth which had proved a vain anchorage for its feet, for larva and clod together were dragged for a long distance through the grass. At last it seized one stalk so firmly that its enemy could not drag it farther; whereupon, after reconnoitering the ground for a little distance, the latter disappeared, but shortly returned with a companion, by whose aid the larva was detached. This done, the helper went his way, while the abductor proceeded with his captive till lost to view.

Pearls and their Origin.—People are still to be found who believe in the myth which ascribes to pearls a sort of animal nature—being born of other pearls, feeding like other animals, and growing larger by the conversion of food into their own substance. A glass tube purporting to contain some of these growing pearls and certain "grains of rice," on which they fed, was lately sent from Australia to Mr. Frank Buckland, who in turn placed it in the hands of a competent conchologist, Mr. Hugh Owen, for examination. Mr. Owen, honestly desirous of dissipating the crass ignorance which alone makes belief in such absurdities possible, takes the trouble to state briefly, in "Land and Water," the natural history of pearls, in substance as follows: Pearls are concretions found either attached to the interior of certain bivalve shells, or enveloped in the folds of the mantle of the animal that inhabits the shell; the latter are most valued. All pearls are formed of the same substance as that lining the inner surfaces of the shells in which they are formed. The peculiar luster is caused by alternate layers of thin membrane and carbonate of lime, and depends on very minute undulations of the layers. The most valuable pearls are found in the soft portions of the mollusca, and are believed to be originally a grain of sand, or some other irritating substance, which the animal covers with a nacreous deposit. That this is the correct theory is seen on cutting or slitting pearls, when each one is found to have a foreign body as a nucleus. Such being the natural history of pearls, the story of "young pearls feeding on rice"

should not be heard outside of the nursery. It may be added that the "rice-grains" in the collection presented to Mr. Buckland are identified by Mr. Owen as marine shells of the genus *Cypræa*, the end or apex of each being carefully filed or ground off to represent the effect of having been fed on by the pearls.

Survival of Serious Brain Injury in a Pigeon.—A remarkable case of recovery of all the faculties in a pigeon from which four fifths of the upper portion of the cerebrum had been removed, is recorded by Dr. J. H. McQuillen, in the "Proceedings" of the Academy of Natural Sciences of Philadelphia. The author, who is Professor of Physiology in the Philadelphia Dental College, on February 4th of last year, exposed the cerebrum of a pigeon, and cut out four fifths of the upper portion in slices: this he did in illustrating to his class the fact that the sensorium thus exposed could be cut, pinched, or burned, without any sign of pain on the part of the animal. The usual phenomena followed, viz., profound stupor, the bird standing motionless on the table, with eyes closed, head sunk between the shoulders, and feathers ruffled. At the close of the demonstration, this pigeon was given to Professor Emily White, M. D., of the Women's Medical College, with the request that an effort should be made to keep the bird alive, and ascertain whether the mutilated organ would regain its functions. In March a note was received from Professor White, in which she stated that the pigeon had apparently recovered all its faculties. "He is," it was added, "perhaps less excitable than normal, and seems perfectly tame, but bright." Dr. McQuillen at once sent for the bird, and observed with surprise the complete recovery of the voluntary movements of walking and flying, the power of feeding itself and drinking as usual, and the general manifestations of intelligence. The bird continued in full possession of its faculties for six months, and then was put to death and an examination made. On removing the scalp a fibrous structure, analogous to pericranium, was found, occupying the place from which the bone had been removed in making the vivisection. Cutting this away, a small amount of fluid escaped, and the cranial cavity thus exposed was found occupied by a white substance resembling the cerebral structure that had been removed six months before. Placing a section of the upper portion of this, which had been stained with hematoxyline, under the microscope, a number of bipolar cells characteristic of the gray structure were observed.

Pigments of the Hair.—By treating with dilute sulphuric acid different kinds of human hair, Mr. H. C. Sorby obtains three distinct pigments, a red, a yellow, and a black. The red pigment is probably convertible by oxidation into the yellow. Very red hair is characterized by the presence of the red constituent unmodified by any other coloring substance; golden hair has less of the red and more of the yellow pigment; in sandy-brown hair the black and red constituents are associated with a large proportion of the yellow; in dark-brown hair the black pigment is present in larger quantity, while in black hair this dark substance predominates over the rest. Singularly enough, Mr. Sorby found in the hair of a negro about the same proportion of the red pigment as in the very red hair of a European. If in this case the development of the black pigment had been checked by any cause, he would have presented the curious spectacle of a red-headed negro.

Wallace's Theory of Zoölogical Derivation.—To illustrate Wallace's theory of the derivation of all animals from the north, a writer in "Nature" designed a map of the world on a polar projection, the northern hemisphere being projected somewhat beyond the southern tropic. This map clearly shows how the land-surface of the globe is built around the pole, and exhibits the extremities of America, Africa, and Australia, extending into the great ocean. If, now, the subdivisional regions (zoölogically) of each of these three great projections, and of the whole, be marked in colors, a succession of zoölogical strata (so to speak) appears. By carrying an ideal section from the supposed center of creation in the north through either of these three great extremities, and thence to the nearer and afterward the more remote of their dependencies, we pass in

each case through zoölogical strata of different types, until we arrive at those where no land mammals are to be found at all. And this succession in space, as evidenced by geography, corresponds in a rough way with the succession in time as revealed by geology: 1. As we recede in distance, we meet with increased dissimilarity. 2. This dissimilarity partakes of a recession in type. 3. Some of these geographical districts seem to have their counterparts in geological periods. The Ethiopian region, as Wallace has shown, presents us with the exiled Miocene fauna of Europe. Eocene forms may be seen in its dependency of Madagascar. Highly isolated Australia, with its marsupials, etc., appears as if it were still in the secondary age. Oceanic islands, such as New Zealand, give no land mammals at all. In others, the reptiles "possess the land."

Antiquity of the Practice of Inoculation.—Inoculation as a means of mitigating the severity of small-pox was practiced in Eastern countries ages before its introduction into the West by Lady Mary Wortley Montagu. The Chinese appear to have practiced it as early as the sixth century. Small-pox is by the Chinese called "heaven's flowers," and their term for inoculation is "cultivating heaven's flowers." Their mode of procedure is to pulverize the scabs taken from a small-pox patient, and to blow the powder thus obtained up the nostril of the child. The powder is injected into the left nostril in the case of a boy, and into the right in the case of a girl. It is impossible to tell whether the disease induced will be severe or not. In some years there are few if any deaths, at other times the mortality is much the same as that from small-pox. A lucky day is carefully chosen for the operation, and at a time when the child is in good health. No particular rules are observed in selecting the matter, except that it is always taken from a mild case of the disease. Gradually, however, vaccination is coming into use in China. The suspicion with which vaccination was formerly regarded by the people as a subtle device of the foreigners to destroy the inhabitants of the Central Flowery Kingdom is dying out, and Dr. Osgood, of Foochow, who has every opportunity of knowing, says that "vaccination is gaining ground every year, and is destined in time to drive out inoculation." But the process of substitution must necessarily be very slow in so strictly conservative a country as the Chinese Empire.

NOTES.

Among the results of the labors of the United States Fish Commission during the year 1878 is to be reckoned the discovery of fifty new species of fishes in our Atlantic waters. These species are enumerated by Messrs. G. Brown Goode and Tarleton H. Bean, in the "American Journal of Science." Full descriptions of the fishes, with discussions of sundry questions of classification, will appear in the publications of the United States National Museum.

A new danger to health is found in the use of artificial flowers colored with aniline dyes. The bronze-green and other colors now so much in vogue are not "fixed," and the dye is apt to be transferred to the skin of the head, producing much annoyance, unpleasant irritation, or even inflammation.

Professor Leidy, having examined with the microscope a "black mildew" found growing on brick walls in shaded situations, found it to be a species of *alga* closely allied to *Protococcus viridis*, which gives the bright-green color to the trunks of trees, fences, etc. The species which produces the black discoloration may be only *viridis* in a different state, but, until it is proved to be such, he proposes to distinguish it by the name of *Protococcus lugubris*. The latter consists of minute round or oval cells, from 0·006 to 0.009 millimetre in diameter, isolated or in pairs or in groups of four, the result of division; or it occurs in short irregular chains of four or more cells up to a dozen, occasionally with a lateral offset of two or more cells. In mass, to the naked eye, the *alga* appears as an intensely black powder.

In certain districts of Austria where cretinism exists the skulls of the wretches who have been afflicted with that disease are disinterred a few years after death and preserved by their nearest relatives. A like custom prevailed in Peru in times prior to the discovery of America, as we learn from an article in "La Nature," on the Anthropological Exposition lately held in Paris. Two crania were there exhibited, one of them overlaid with gold and the other with silver. The evidences of cretinism in these skulls are unmistakable, and there can be no doubt that they were at one time objects of pious care. The custom in Austria is to

write the name of the deceased cretin across the forehead of the skull, to paint a fillet of leaves and flowers around the latter, and to engrave on it different emblems, as crosses and the like.

When the committee of scientific men who had been charged with the organization of the Anthropological Exposition connected with the Paris World's Fair called on M. Krantz, the Director-General, to obtain his approval of the plan, his reply was: "Gentlemen, I must confess that I have never heard anything but evil about you. This has satisfied me that your work is of value; this has led me to infer that it is useful, and has given me a bias in its favor."

To test the correctness of the statement which has been made that the leather covers of books in libraries are injured by the combustion products of coal-gas, Professor Wolcott Gibbs has examined the books in different libraries, in some of which gas is burned, in others not; and his conclusion is that the effects supposed to be attributable to the burned gas are in reality due to other causes. The trouble is more probably in the tanning of the leather than in the action of the gas; the older kinds of leather used by binders being of poor quality and badly tanned.

In 1871 a vessel laden with Italian marble was wrecked off Long Island. Specimens of this marble, presenting certain very interesting appearances, having been presented to the Peabody Museum of Yale College, they are described in the "American Journal of Science" by Professor Verrill. The exposed portions of the slabs are, he says, thoroughly penetrated to the depth of one or two inches by the crooked and irregular borings or galleries of the sponge *Cliona sulphurea* (V.), so as to reduce it to a complete honeycomb, readily crumbled by the fingers. Beyond these borings the marble is perfectly sound and unaltered. Professor Verrill has long been familiar with the fact that this sponge can destroy the shells of oysters, mussels, etc., but this is the first instance he has noticed of its attacking marble or limestone, for calcareous rocks do not occur along the portions of our coast inhabited by it. Its ability to rapidly destroy such rocks might have a practical bearing in case of submarine structures of limestone or similar material.

"Blasting gelatine," a new explosive agent, is formed by dissolving collodion cotton in nitro-glycerine in the proportion of 10 per cent. of the former to 90 per cent. of the latter. The product is a gelatinous, elastic, transparent, pale-yellow substance, having the density of 1·6 and the consistence of a stiff jelly. "It is in itself," says the "Engineering and Mining Journal," "much less easily affected than Kieselguhr dynamite, but it may be made far more insensible to mechanical impulse by an admixture of 4 to 10 per cent. of camphor. Experiments prove that the new explosive possesses weight for weight 25 per cent., and bulk for bulk 40 per cent., more explosive power than ordinary dynamite."

Professor Emerson Reynolds proposes this simple test of the purity of water: Put into a perfectly clean bottle of white glass one half litre of water, and a piece of loaf-sugar the size of a pea. Then set it on a sheet of white paper in a window exposed to the sun's rays for eight or ten days. If the water is then turbid it contains foreign substances, impurities, probably sewage.

The Marquis of Tweeddale (Hay), Fellow of the London Royal Society and President of the Zoölogical Society, who died last December, at the age of fifty-five years, was a distinguished ornithologist, being one of the best authorities on the birds of India and the Eastern Archipelago. He was a voluminous contributor to the "Ibis," the "Proceedings" and the "Transactions" of the Zoölogical Society, the "Annals of Natural History," and other scientific periodicals.

Sixty years ago a farmer in Monmouth County, New Jersey, planted with locust-trees several acres of untillable land; the result of that planting, as related in the "Gardener's Monthly," is a good lesson in rural economy. Years ago the trees first set out were cut down, but the second growth quickly covered the ground, and last year this second growth was cut. This timber was worked into farm-fence posts, garden-fence posts, and fence-stakes, the whole worth about $2,000—the cost of cutting being offset by the fuel value of the tops which were unfit for other uses. One grove thirty-seven hundredths of an acre in area yielded 1,400 "five-hole posts," 150 garden-fence posts, and 200 fence-stakes: at this rate the product of an acre would be about $3,000.

James McNab, Curator of the Botanic Garden at Edinburgh, died in November, aged sixty-eight years. His predecessor in the curatorship was his father, from whom McNab received a thorough botanical training. Deceased was a frequent contributor to horticultural and scientific periodicals.

Colonel P. W. Norris lately exhibited at Detroit the head and antlers of a huge animal killed in the Yellowstone National Park. The antlers are webbed, and the animal to which they belong is believed to have been a cross between the elk and the moose.

SIR HUMPHRY DAVY.

THE

POPULAR SCIENCE MONTHLY.

APRIL, 1879.

JOHN STUART MILL.

By ALEXANDER BAIN, LL. D.,

PROFESSOR IN THE UNIVERSITY OF ABERDEEN.

I.

I PROPOSE to review the life and character of John Stuart Mill. In addition to what all the world may know, I am aided by personal recollections extending over the second half of his life, and by documents in the possession of his family for some of the earlier portions.

My plan requires me to recall the account given in the "Autobiography" of the successive stages of his early education. There is a sort of pause or break at his eighth year, when he began Latin. His years from three to eight are occupied with Greek, English and arithmetic; the Greek, strange to say, taking precedence. His earliest recollection of all, we are led to suppose, although not explicitly affirmed, is his committing to memory lists of Greek words written by his father on cards. He had been told that he was then three years old. Of course reading English, both printed and written, was supposed: and we have to infer that he had no recollection of that first start of all, which must have been taken before he completed his third year. And, judging from the work gone through by his eighth year, he can not be far wrong in putting down the date of the Greek commencement.

A letter from his father to Bentham, dated July 25, 1809, affords us a momentary glimpse of him at the age of three years and two months. It was the occasion of the first visit to Bentham at Barrow Green. The letter is an apology for not being able to come on the day previously arranged, and is full of rather heavy joking about the domestic obstructions. The passage to our present purpose is this:

"When I received your letter on Monday, John, who is so desirous to be your inmate, was in the room, and observed me smiling [at Bentham's fun] as I read it. This excited his curiosity to know what it was about. I said it was Mr. Bentham asking us to go to Barrow Green. He desired to read that. I gave it to him to see what he would say, when he began, as if reading—Why have you not come to Barrow Green, and brought John with you?" The letter closes—"John asks if Monday (the day fixed) is not to-morrow." Not much is to be made of this, except that the child's precocious intellect is equal to a bit of waggery. The remark may seem natural, that if he were then learning his Greek cards he might actually have read the letter; but no one that ever saw Bentham's handwriting would make that remark. As I take it, the interest of the scene lies in disclosing a sunny moment in the habitually stern relationship of the father and son.

As an introduction to the next contemporary landmark of his progress, I need to quote from himself the account of his earliest reading. He says nothing of English books till he has first given a long string of Greek authors—Æsop's Fables, the Anabasis, Cyropædia, and Memorabilia of Xenophon, Herodotus, some of Diogenes Laertius, part of Lucian, two speeches of Isocrates; all these seem to have been gone through before his eighth year. His English reading he does not connect with his Greek, but brings up at another stage of his narrative. From 1810 to 1813 (age, four to seven) the family had their residence in Newington Green, and his father took him out in morning walks in the lanes toward Hornsey, and in those walks he gave his father an account of his reading; the books cited being now histories in English—Robertson, Hume, Gibbon, Watson's Philip the Second and Third (his greatest favorite), Hooke's History of Rome (his favorite after Watson), Rollin in English, Langhorne's Plutarch, Burnet's Own Time, the history in the Annual Register; he goes on, after a remark or two, to add Millar on the English Government, Mosheim, McCrie's Knox, a quantity of voyages and travels—Anson, Cook, etc.; Robinson Crusoe, Arabian Nights, Don Quixote, Miss Edgeworth's Tales, and Brooke's Fool of Quality. I repeat that all this was within the same four years as the Greek list above enumerated. At a later stage, he speaks of his fondness for writing histories; he successively composed a Roman History from Hooke, an abridgment of the Universal History, a History of Holland, and (in his eleventh and twelfth years) a History of the Roman Government. All these, he says, he destroyed. It happens, however, that a lady friend of the family copied and preserved the first of these essays, the Roman History; upon the copy is marked his age, six and a half years, which would be near the termination of the two formidable courses of reading now summarized. The sketch is very short, equal to between two and three of the present printed pages, and gives but a few scraps of the earlier traditions. If it is wonderful for the writer's age, it also shows that his enormous reading had as yet done

little for him. He can make short sentences neatly enough; he gives the heads of the history, in the shape of the succession of kings and consuls; and, in imitation of his author, he supplies erudite and critical notes.[1]

It was about the age when he wrote this history that he was invited to an interview with Lady Spencer (wife of Lord Spencer, then at the head of the Admiralty), her curiosity being roused by the accounts of him. His conversation on the occasion turned chiefly on the personages of Roman history, whose characters he fluently hit off.

My next document is a letter, in his own hand, dated September 13, 1814. He was now eight years and four months. He was in the second stage of his studies, when he had begun Latin, and had extended his reading in Greek to the poets, commencing with the Iliad. He was also teaching his sister, two years younger than himself. The event that gave rise to the letter was the migration of the whole family to Bentham's newly acquired residence, Ford Abbey, in Somersetshire. I will give a part and abridge the rest. His correspondent was some intimate friend of the family unknown.

I have arrived at Ford Abbey without any accident, and am now safely settled there. We are all in good health, except that I have been ill of slight fever for several days, but am now perfectly recovered.

It is time to give you a description of the abbey. There is a little hall and a long cloister, which are reckoned very fine architecture, from the door, and likewise two beautiful rooms, a dining-parlor and a breakfast-parlor adorned with fine drawings within one door; on another side is a large hall, adorned with a gilt ceiling; and beyond it two other rooms, a dining and drawing room, of which the former contains various kinds of musical instruments, and the other is hung with beautiful tapestry.

To this house there are many staircases. The first of them has little remarkable up it, but that three rooms are hung with tapestry, of which one contains a velvet bed, and is therefore called the velvet room. The looking-glass belonging to this room is decorated with nun's lace.

Up another staircase is a large saloon, hung with admirable tapestry, as also a small library. From this saloon issues a long range of rooms, of which one is fitted up in the Chinese style, and another is hung with silk. There is a little further on a room, which, it is said, was once a nursery; though the old farmer Glyde, who lives hard by, called out his sons to hear the novelty of a

[1] The beginning runs thus (heading "First Alban Government: Roman Conquest in Italy): "We know not any part," says Dionysius of Halicarnassus, "of the history of Rome till the Sicilian invasions. Before that time the country had not been entered by any foreign invader. After the expulsion of Sicilians, Iberian (?) kings reigned for several years; but in the time of Latinus, Æneas, son of Venus and Anchises, came to Italy, and established a kingdom there called Albania. He then succeeded Latinus in the government, and engaged in the wars of Italy. The Rutuli, a people living near the sea, and extending along the Numicius up to Lavinium, opposed him. However, Turnus their king was defeated and killed by Æneas. Æneas was killed soon after this. The war continued to be carried on chiefly against the Rutuli, to the time of Romulus, the first king of Rome. By him it was that Rome was built."

child crying in the abbey! which had not happened for the whole time he had lived here, being near thirty years. Down a staircase from here is a long range of bedrooms, generally called the Monks' Walk. From it is a staircase leading into the cloisters. The rest of the house is not worth mentioning. If I was to mention the whole it would tire you exceedingly, as this house is in reality so large that the eight rooms on one floor of the wing which we inhabit, which make not one quarter of even that floor of the whole house, are as many as all the rooms in your house, and considerably larger.

I have been to the parish church which is at Thornecomb. Mr. Hume has been here a great while. Mr. Koe came the other day, and Admiral Chietekoff is expected. Willie and I have had rides in Mr. Hume's curricle.

He goes on to say—"What has been omitted here will be found in a journal which I am writing of this and last year's journeys." He then incontinently plunges again into descriptive particulars about the fish-ponds, the river Axe, the deer-parks, the walks, and Bentham's improvements. The performance is not a favorable specimen of his composition; the handwriting is very scratchy, and barely shows what it became a few years later. The reference to Joseph Hume's visit has to be connected with the passage at arms between the elder Mill and Bentham, which I had formerly occasion to notice ("Mind," viii., pp. 525, 526).

By far the most important record of Mill's early years is his diary during part of his visit to France, in his fifteenth year; and from this I hope to illustrate with some precision the real character of his acquisitions and his intellectual power at that age. A very valuable introduction to this diary was lately brought to light by Mr. Roebuck, who had fortunately preserved a letter of Mill's that he had received from Jeremy Bentham's amanuensis in 1827. It was addressed to Bentham's brother, Sir Samuel Bentham, and it is dated July 30, 1819, his age being thirteen years and two months. The letter begins thus:

My Dear Sir: It is so long since I had the pleasure of seeing you that I have almost forgotten when it was, but I believe it was in the year 1814, the first year we were at Ford Abbey. I am very much obliged to you for your inquiries with respect to my progress in my studies; and as nearly as I can remember, I will endeavor to give an account of them from that year.

He then goes on to detail his reading for the successive years from 1814. I do not print the details, but will compare them with the "Autobiography," and indicate agreements and differences. In the year 1814 (by the letter), he read, in Greek, Thucydides and Anacreon (an odd coupling), and, *he believed*, the Electra of Sophocles, the Phœnissæ of Euripides, the Plutus and the Clouds of Aristophanes, and the Philippics of Demosthenes; in Latin, only the Oration of Cicero for Archias, and part of the pleading against Verres. In Mathematics, he was reading Euclid; he began Euler's Algebra, and worked at Bonnycastle; also some of West's Geometry. In 1815, his reading was Homer's

Odyssey, Theocritus, some of Pindar, the Orations of Æschines and Demosthenes on the Crown. In Latin: first six books of Ovid's Metamorphoses, first five books of Livy, the Bucolics and the first six books of the Æneid of Virgil, and part of Cicero de Oratione. In Mathematics: finished the six books of Euclid together with the Eleventh and Twelfth, and the Geometry of West; studied Simpson's Conic Sections, and West's Conic Sections, Numeration and Spherics; and, in Algebra, Hessy's Algebra and Newton's Universal Arithmetic, in which last he performed all the problems without the book, and most of them without any help from the book.

1816. Greek: part of Polybius, Xenophon's Hellenics, the Ajax and Philoctetes of Sophocles, the Medea of Euripides, the Frogs of Aristophanes, and great part of the Anthologia Græca. Latin: all Horace, except the Epodes. Mathematics: Stewart's Propositiones Geometricæ, Playfair's Trigonometry at the end of his Euclid, "Geometry" in the Edinburgh Encyclopædia, and Simpson's Algebra.

1817. Greek: Thucydides (the second time), many Orations of Demosthenes, all Aristotle's Rhetoric, of which he made a synoptical table. Latin: Lucretius, all but the last book, Cicero, Ad Atticum, Topica, and De Partitione Oratoria. Mathematics: "Conic Sections" in Encyclopædia Britannica; Simpson's Fluxions, Keill's Astronomy, and Robinson's Mechanical Philosophy.

1818. Greek: more of Demosthenes; four first books of Aristotle's Organon, tabulated in the manner of the Rhetoric. Latin: all Tacitus (except the Dialogue on Oratory), great part of Juvenal, beginning of Quintilian. Mathematics: Emerson's Optics, Trigonometry by Professor Wallace, solution of problems, beginning of article on Fluxions in the Edinburgh Encyclopædia. Began to learn Logic, read several Latin treatises—Smith, Brerewood, Du Trieu, part of Burgersdicius, Hobbes.

1819 (the year when the letter was written). Greek: Plato's Gorgias, Protagoras, and Republic. Latin: Quintilian, in course of reading. Mathematics: Fluxions, problems in Simpson's Select Exercises. Also, he is now learning Political Economy.

While this enumeration is much fuller than that in the "Autobiography," it omits mention of several works there given: as Sallust, Terence, Dionysius, and Polybius. The private English reading is in both: chiefly Mitford's Greece, Hooke and Ferguson's Rome, and the Ancient Universal History. His composing Roman History, as well as Poetry and a Tragedy, is given in both. The Higher Mathematics of this period is but slightly given in the "Autobiography."

This letter was doubtless intended not merely to satisfy Sir Samuel's curiosity as to his precocity of acquirement, but also to pave the way for the invitation to accompany him to France the following year (1820).

A carefully written diary, extending over the first five months of

his stay in France, is by far the most satisfactory record that is now to be had of his youthful studies.[1]

We have his reading and all his other occupations recorded day by day, together with occasional reflections and discussions that attest his thinking power at that age. The diary was regularly transmitted to his father. At first he writes in English; but, as one of the purposes of his visiting France was to learn the language, he soon changes to French. Printed in full it would be nearly as long as this article. I shall endeavor to select some of the more illustrative details.

He left London on May 15, 1820, five days before completing his fourteenth year. He traveled in company with Mr. Ensor, an Irish gentleman, a friend of his father's. The diary recounts all the incidents of the journey—the coach to Dover, the passage across, the thirty-three hours in the diligence to Paris. He goes first to a hotel, but, on presenting an introduction by his father to M. Say, he is invited to the house of that distinguished political economist. The family of the Says—an eldest son, Horace Say, a daughter at home, the youngest son, Alfred, at school *en pension*, but coming home on Saturday and Sunday, and their mother—devote themselves to taking him about Paris. He gives his father an account of all the sights, but without much criticism. His moral indignation bursts forth in his account of the Palais Royal, an "immense building belonging to the profligate Duc d'Orleans, who, having ruined himself with debauchery, resolved to let the arcades of his palace to various tradesmen." The Sunday after his arrival (May 21) is so hot that he did not go out, but played at battledore and shuttlecock with Alfred Say. He delivers various messages from his father and Bentham, and contracts new acquaintances, from whom he receives further attentions. The most notable was the Count Berthollet, to whom he took a paper from Bentham. Madame Berthollet showed him her very beautiful garden, and desired him to call on his return; he learned afterward that he was to meet Laplace. On the 27th, after nine days' stay in Paris, he bids good-by to Mr. Ensor and the Says, and proceeds on his way to join the Bentham family, then at a chateau belonging to the Marquis de Pompi-

[1] Sir Samuel Bentham, the brother of Jeremy Bentham, was himself a remarkable man. His first service was in the Russian Army, where his soldiering was intermingled with suggestions for improvements of all sorts, and especially mechanical inventions, for which he had a pronounced genius. One of his proposals to the Russian government was the Panopticon prison, of which he was the originator. He came over to England in 1795, and received from our Government the appointment of Superintendent of the Dockyard at Portsmouth, where his talent for invention had scope in the improvement of the navy. He married the daughter of an early friend of his brother, Dr. John Fordyce, a physician in London, called by Bentham "one of the coldest of the cold Scotch"; this lady had the domestic supervision of Mill for more than a year. On retiring from the Dockyard, Sir Samuel bought an estate in the South of France for the sake of a residence there; and this led to his inviting Mill to reside with him, first at Toulouse, and afterward at Montpellier. The family consisted of one son, Mr. George Bentham, the well-known botanist, and three daughters—all older than Mill.

gnan, a few miles from Toulouse. The journey occupies four days, and is not without incident. He makes a blunder in choosing the cabriolet of the diligence, and finds himself in low company. At Orleans, a butcher, with the largest belly he had ever seen, came in and kept incessantly smoking. On the third day he is at Limoges, and breakfasts in company with a good-natured gentleman from the interior; but his own company does not much improve; the butcher leaves, but a very dirty *fille*, with an eruption in her face, keeps up his annoyance. The following day a vacancy occurs in the interior, and he claims it as the passenger of longest standing; a lady contests it with him, and it has to be referred to the *maire;* the retiring passenger, a young *avocat*, pleading his case. He is now in good company, and his account of the successive localities is minute and cheerful.

He arrives at his destination at 2 A. M., the 2d of June, is received by Mr. George Bentham, and meets the family at breakfast. They take him out for a walk, and he does no work that day, but begins a letter to his father. Next day he makes an excursion to Toulouse, spends the night there, and gives up a second day to sight-seeing; there was a great religious procession that day. He makes the acquaintance of a Dr. Russell, resident at Toulouse, with whose family he afterward associates. The following day, the 5th, he sees the Marquis and Madame de Pompignan, the proprietors of the château. On the 6th, he commences work; and now begins our information as to his mode of allocating his time to study. The entry for this day merely sets forth that he got up early; went into the library; read some of Lucian (who is his chief Greek reading for the weeks to follow); also some of Millot, by Mr. George's advice; "learned a French fable by rote"—the beginning of his practice in French. 7th. "Learned a very long fable; wrote over again, with many improvements, my Dialogue, part I." This dialogue frequently comes up, but without further explanation. We must take it as one of his exercises in original composition, perhaps in imitation of the Platonic Dialogues. 8th. Engaged with Mr. G. in arranging the books of the library, which seems to have been set as a task to the boys. "Wrote some of dialogue; learned a very long fable by heart; resolved some problems of West (Algebra); did French exercises (translating and so forth)." 9th. "Breakfasted early and went with Sir S. and Lady Bentham in the carriage to Montauban; took a volume of Racine in my pocket, and read two plays;" remark his reading *pace*. On returning home he reads a comedy of Voltaire. 10th. "Before breakfast, learned another fable, and read some of Virgil. After breakfast, wrote some of my Dialogue, and some French exercises. Wrought some of the Differential Calculus. Read a tragedy of Corneille." 11th. "Learned another fable; finished my Dialogue. If good for nothing beside, it is good as an exercise to my reasoning powers, as well as to my invention, both which it has tried extremely." We may be sure that it aimed at something very high. "Wrote some

French exercises; began to learn an extremely long fable. Read a comedy of Molière, and after dinner a tragedy of Voltaire. Took a short walk by myself out of the pleasure grounds." 12th. "Rose very early. Sir S. B. and Mr. G. went in the carriage to Toulouse. Before breakfast, I wrote some French exercises, read some of Lucian's Hermotimus. Revised part of my Dialogue. After breakfast went with the 'domestique' Piertot to see his Metairie and his little piece of land and help him to gather cherries. After returning I finished the long fable." Then follows an apology for not working at his mathematics; Sir Samuel's books are not unpacked, and in the library of the house he finds chiefly French literature, and hence his readings in Racine, etc. Another tragedy read to-day. 13th. Before breakfast assists Mr. G. in packing. Wrote French exercises, read Voltaire and Molière. It is by the advice of the family that he reads plays, for the sake of dialogue. After dinner, he takes a long walk on the hills behind Pompignan; on his return falls in with the Garde Champêtre, who communicates all about himself and his district. Weather now hot. 14th. Could not get into the library. Walked about the grounds with Mr. G. and one of his sisters; came in and wrote French exercises. Begins a new study—to master the Departments of France. Reads Lucian. 15th. Got up early; began his Livre Statistique of the Departments—chief towns, rivers, populations, etc. Learns by heart the names of the departments and their capital towns. Acting on a suggestion of Lady B., he reads and takes notes of some parts of the Code Napoleon. Meets the Russell family at dinner, and walks with them. 16th. Up early, walked out, reads a tragedy of Voltaire. A mad dog has bitten several persons. More of Code Napoleon; Virgil; French exercises. Here he concludes what is to make his first letter to his father, and appends to the diary a dissertation on the state of French politics; the then exciting topic being the Law of Elections. We are surprised at the quantity of information he has already got together, partly we may suppose from conversations, and partly from newspapers; but he never once mentions reading a newspaper; and his opportunities of conversation are very much restricted by incessant studies. Besides passing politics, illustrated by anecdotes, he has inquired into education, the statistics of population, and the details of the provincial government.

I continue the extracts from the Diary. June 17th. Late in bed, not knowing the time. One of Sir Samuel's daughters has given him Legendre's Geometry, to which he applies himself, at first, for the sake of French mathematical terms. Performs an investigation in the Differential Calculus. A short walk. After dinner, a tragedy of Corneille. 18th. Rose early. Wrote French exercises, and read Voltaire. It is a fête day (Sunday), and the peasants danced in the pleasure grounds before the house. After breakfast, finished exercises, then walked with the family in the grounds. Received from Mr. G. a lecture on Botany (probably the beginning of what became his favorite

recreation). Wrote out the account of his expenditure since leaving Paris, gives the items, amounting to one hundred and forty-eight francs. Describes the peasants' dance. 19th. Rose early. Finished the Hermotimus of Lucian, and yesterday's tragedy; wrote French exercises. After breakfast, assisted in packing up, as the family are leaving the château for a residence in Toulouse. Finds time before dinner for another tragedy of Voltaire. In the evening, took to an article in the Annales de Chimie (his interest in Chemistry being now of four years' standing). 20th. Occupied principally with preparations for leaving. 21st. The house in confusion. Still he does a good stroke of French reading. 22d. In bed till after nine; could not account for it. The confusion is worse confounded; doesn't know what to do about his books; is now debarred from the library. Has taken out his exercise-book from his trunk, and written a considerable portion of exercises. Has added to his Livre Statistique; the Departments are now fully in his head: next topic the course of the Rivers—an occupation when he has nothing else to do. 23d. Rose at three o'clock, to finish packing for departure. As there could be no reading, at five he takes a long country walk to Fronton; gives two pages of the diary to a description of the country and the agriculture. Books being all locked up, he expects to feel ennui for a little time. Writes some of his Livre, converses with two intelligent workmen, gives particulars. After dinner, walks to the village of —— on the Garonne, describes the river itself in the neighborhood. In the evening, being the "Veille de St. Jean," saw the fires lighted up in the district. 24th. Lay in bed purposely late, having nothing to do. M. Le Comte (son of the proprietor) comes in, and politely offers him the key of the library, shows him a book of prints; he also scores a tragedy of Voltaire. As this is the last day before moving to Toulouse, he makes a pause, and dispatches his seven days' diary to his father, accompanied with a short letter in French to R. Doane, Bentham's amanuensis, chiefly personal and gossipy; none of his letters to Mr. Doane take up matters of thought. 25th. Rose at half past two for the journey. He walks out on foot, to be overtaken by a char-à-banc, with part of the family. One of the girls drove part of the way, and gave him the reins for the remainder, as a lesson in driving. They take up their quarters in one of the streets, where they have a very good "Apartment" (I suppose a flat); still, after the château, they feel considerably cramped; his room a little hole, which he proceeds at once to arrange, having got shelves for his books. Same night finishes Lucian's *Βίων Πρᾶσις*, and reads some of Thomson's Chemistry, which is part of his own library.

The family remains in Toulouse for some time. We have his diary for nearly six weeks. It is the intention of the Benthams to find him, not merely a French master, but instruction in various accomplishments—music, dancing, fencing, horsemanship. It is some time before the arrangements are made, so that his first days are purely devoted to

book studies; and the diary is an exact record of the nature, amount, and duration of his reading, very nearly as at home. It also gives occasional glimpses of his thinking power at the age he has now reached. It is further interesting as exhibiting his tone toward his father. I will merely quote enough to complete the illustration of these various particulars.

26th. Besides a mass of French reading, reports two eclogues of Virgil and the Alectryon of Lucian. Remarks that having so much French to do, he cannot read Latin and Greek and study Mathematics every day, and means to give one day to Mathematics and one to Latin and Greek. 27th. Rose early. Begins the practice of going every morning to bathe in the Garonne, a little above the town: he is accompanied regularly by Mr. George, and on this occasion by Dr. Russell's boys. To-day reads Legendre's Geometry. Gives a subtile criticism of the author's method, which he thinks excellent; praises the derivation of the Axioms from the Definitions, as conforming to Hobbes's doctrine that the science is founded on Definitions. Approves also of the way the more elementary theorems are deduced. Learned a very long French fable. Solved a problem in West's Algebra that had baffled him for several years. Mr. George has already engaged for him the best dancing-master in the place. 28th. (Classical day.) Bathing as usual. Two eclogues of Virgil, and a French grammatical treatise on Pronouns. Read some more of Legendre (resolution broken through already): thinks his line of deduction better than Euclid, or even than West. Studies Bentham's Chrestomathic Tables (a vast and minute scheme of the divisions of knowledge). Began the Vocalium Judicium of Lucian. Goes for a second dancing-lesson. 29th. Rather late in returning from the river. An eclogue of Virgil; finishes the Vocalium Judicium; wrote French exercises, read some of Boileau's little pieces; is to have Voltaire's works soon; asks Mr. George about a Praxis in the higher Mathematics, having performed over and over again all the problems in Lacroix's Differential Calculus. Resolves more problems of West, including the second of two that had long puzzled him. After dinner began Lucian's Cataplus. 30th. Two eclogues of Virgil; finished Cataplus; more of Legendre, discovered a flaw in one of his demonstrations; wrote French exercises; read some of Sanderson's Logic; also some of Thomson's Chemistry. July 1. Treatise on Pronouns finished; Sanderson; began Lucian's Necyomantia; French exercises; finished first book of Legendre; Thomson's Chemistry. Dancing-lesson. A singing-master engaged. 2d. Georgics of Virgil, ninety-nine lines; more of the Necyomantia before breakfast. After breakfast, Thomson's Chemistry. Wrote Livre Geographique. In the evening the whole family go to Franconi's Circus; describes the exploits. Has to be measured for a new suit, French fashion; his English suit being inadmissible, trousers too short, waistcoat too long. The Russells call in the evening, and there is an earnest talk on politics, English and

French, which he details. 3d. A breakdown in the char-à-banc that takes them to the river. Has now got a singing-master, and takes first lesson in *Solféges et Principes de Musique.* Again at Franconi's, and full of the performance; for a wonder, no studies recorded. 4th. Rose at five; home from bathing, etc., at half past seven. Has obtained Voltaire's Essai sur les Mœurs, which he includes among his stated reading: breakfast at quarter to nine: at half past nine, begins Voltaire where he left off in England, read six chapters in two hours; Virgil's Georgics, forty-seven lines; at quarter past twelve began a treatise on French Adverbs; at half past one began the second book of Legendre, read the definitions and five propositions; miscellaneous employments till three, then took second Music-lesson. Dined; family again to Franconi's, but he could not give up his dancing-lesson; this got, he writes French exercises and practices music. 5th. Rose at five; too rainy for bathing. Five chapters of Voltaire; from half past seven till half past eight Mr. G. corrects his French exercises which had got into arrears as regards correction; Music-master came; at half past nine began new exercises (French); puts his room in order; at quarter past eleven took out Lucian and finished Necyomantia; five propositions of Legendre, renewed expressions of his superiority to all other geometers; practiced Music-lessons; Thomson's Chemistry, made out various Chemical tables, the drift not explained; at quarter past three, tried several propositions in West, and made out two that he had formerly failed in; began a table of fifty-eight rivers in France, to show what departments each passes through, and the chief towns on their banks; four, dined; finishes Chemical table; dancing-lesson; supped. Reports that a distinguished music-mistress is engaged at whose house he is to have instrumental practice. 6th. Rose at six; no bathing; five chapters of Voltaire; a quarter of an hour to West's Problems; lesson in Music (*Principes*); problems resumed; breakfasted, and tried problem again till quarter past ten; French exercises till eleven; began to correct his Dialogue, formerly mentioned, till quarter past twelve; summoned to dress for going out to call; has found a French master; at quarter past one returned and corrected Dialogue till quarter past three; Thomson till four (dinner), resumed till six; Mr. G. corrects his French exercises; went out for his French lesson, but the master did not teach on Sundays and Thursdays; back to Thomson till eight; repeated fables to Mr. G., miscellaneous affairs; supped; journal always written just before going to bed. 7th. Rose forty-five minutes past five; five chapters Voltaire till seven; till quarter past seven, forty-six lines of Virgil; till eight, Lucian's Jupiter Confutatus; goes on a family errand; Music-lesson till nine (*Principes*); Lucian continued till half past nine, and finished after breakfast at quarter past ten; a call required him to dress; read Thomson and made tables till quarter past twelve; seven propositions of Legendre; has him over the coals, for his confusion in regard to ratio "takes away a good deal of my opin-

ion of the merit of the work as an elementary work": till half past one, wrote exercises and various miscellanies; till half past two the treatise on Adverbs; till forty-five minutes past three, Thomson; Livre Geographique and miscellanies till five; eats a little dinner, being uncertain, owing to a family event; goes for first lesson to music-mistress, a lady reduced by the Revolution, and living by her musical talents; henceforth to practice at her house daily from eleven to twelve, and take a lesson in the evening; dined on return, then dancing-lesson. 9th. Rose at five; five chapters Voltaire; forty-five minutes past six, Adverbs; forty-five minutes past seven, the Prometheus of Lucian; half past eight till nine, first lesson of *Solfèges* together with *Principes*; continued Prometheus till breakfast; miscellaneous occupation till the hour of music-lesson at Madame Boulet's; home at half past twelve, ten propositions of Legendre; "if anything could palliate the fault I have noticed of introducing the ratio and the measures of angles before the right place, it is the facility which this method gives to the demonstration of the subsequent propositions; this, however, can not excuse such a palpable logical error, etc." Mr. G. is to procure Cagnioli's Trigonometry, but a Praxis in the higher Mathematics is not yet forthcoming. 10th. Starts at four with Mr. G. and the Russells on a day's excursion to the forest of Bouconne, three leagues from Toulouse, the object being to collect plants and insects. Makes his *coup d'essai* at catching butterflies, got only about ten worth keeping; the adventures of the day fully given. 11th. Yesterday's fatigue keeps him in bed late; one chapter of Voltaire; at half past seven, with Mr. G., to begin with his French master, who hears his pronunciation, and sets him plenty of work. Taken with a party to the house of an astronomer, M. Daubuisson, and shown his instruments; then to the house of his brother, a great mineralogist. Returns at two to commence the formidable course of lessons set by the French master. Goes successively to his music-master and music-mistress. Introduces a remark as to the great kindness of the family in constantly, without ill-humor, explaining to him the defects in his way of conducting himself in society: "I ought to be very thankful." 12th. Hears from his father that Lady B. has written a good account of him. Replies in full to the matters in his father's letter; is glad to hear of his article on Government and promises on his return to read it with great attention. Indicates that in future his French lessons will very much engross his time. He is to take the first opportunity of sending the Dialogue, on which he has taken great pains both with expression and with reasoning. Apologises for giving more time to Mathematics than to Latin and Greek.

A fencing-master is now provided for him, and in two days more a riding-master, so that we may have seen him at his best as regards book studies. He keeps these up a few hours every day, but the largest part of the day is taken up with his other exercises. The only thing deserving mention now is the occasional notice of new subjects. Thus,

he begins a treatise on Value, and Sir S. B. is to get Say's book for him. His French master seems to prescribe, among other things, translating from Latin into French, and he takes up the speech of Catiline in Sallust, and afterward some Odes of Horace. There is another day's excursion to the forest of Ramelle, with many incidents. He soon reports having read the last of Lucian, and gives a short review of him, accompanied with high admiration ; Hermotimus he considers a masterpiece of ingenious reasoning. In a letter to his mother he adverts to his progress in music and dancing; he advises his two elder sisters to remit their music till he returns, as he discovers now that they were on a wrong plan. Writes a letter in Latin to those two sisters, correct enough but not very high composition. Begins a Dialogue at the suggestion of Lady B., on the question—whether great landed estates and great establishments in commerce or manufactures, or small ones, are most conducive to the general happiness ; in the circumstances, rather venturesome. The following day began, also by Lady B.'s advice, to write on the Definition of Political Economy. Very much elated by "excellent news of the revolution in Italy." Attends three lectures on modern Greek, and gives his father an account of the departures from the ancient Greek. In the beginning of August the lessons are at an end, the family going for a tour in the Pyrenees. What remains of the diary is occupied with this tour, its incidents and descriptions, and is written in French.

I must, however, advert to an interesting letter from Lady Bentham to his father, dated September 14th. It refers to a previous letter of hers giving particulars of John's progress in French and other branches of acquirement. The family is to reside in Montpellier, and the purpose of the present letter is to recommend to his father to allow him to spend the winter there, and to attend the public lectures of the college. Mr. Bernard, a distinguished chemist, who had visited the Benthams at Toulouse, had taken an interest in him, and sounded his depths and deficiencies, and gives the same opinion. As the party has now been boxed up together for some weeks, his habits and peculiarities had been more closely attended to than ever, and (I quote the words) "we have been considerably successful in getting the better of his inactivity of mind and body when left to himself." This probably refers to his ennui when deprived of books ; it being apparent that, much as was his interest in scenery, he could not as yet subsist upon that alone. The letter goes on—"Upon all occasions his gentleness under reproof and thankfulness for correction are remarkable ; and, as it is by reason supported by examples we point out to him that we endeavor to convince him, not by command that we induce him to do so and so, we trust that you will have satisfaction from that part of his education we are giving him to fit him for commerce with the world at large." Lady Bentham does not omit to add that he must also dress well.

The remainder of the diary serves mainly to show his growing taste

for scenery and his powers of description. He depicts climate, productions, villages, the habits of the people, as well as the views that were encountered. The party make the ascent of Le Pic du Midi de Bigorre, and he is in raptures with the prospect. "Mais jamais je n'oublierai la vue du côte méridionale." In short, to describe its magnificence would need a volume!

We may now conceive with some degree of precision the intellectual caliber of this marvelous boy. In the first place we learn the number of hours that he could devote to study each day. From two to three hours before breakfast, about five hours between breakfast and dinner, and two or three in the evening, make up a working day of nine hours clear; and while at Toulouse scarcely any portion of his reading could be called recreative. His lightest literature was in French, and was intended as practice in the language. Probably at home his reading-day may have often been longer; it would scarcely ever be shorter. For a scholar in mature years eight or nine hours' reading would not be extraordinary; but then there is no longer the same tasking of the memory. Mill's power of application all through his early years was without doubt amazing; and, although he suffered from it in premature ill-health, it was a foretaste of what he could do throughout his whole life. It attested a combination of cerebral activity and constitutional vigor that is as rare as genius; his younger brothers succumbed under a far less severe discipline.

That the application was excessive, I for one will affirm without any hesitation. That his health suffered we have ample evidence, which I shall afterward produce. That his mental progress might have been as great with a smaller strain on his powers, I am strongly inclined to believe, although the proof is not so easy. We must look a little closer at the facts.

I can not help thinking that the rapid and unbroken transitions from one study to another must have been unfavorable to a due impression on the memory. He lost not a moment in passing from subject to subject in his reading: he hurried home from his music-lesson or fencing-lesson to his books. Now, we know well enough that the nervous currents, when strongly aroused in any direction, tend to persist for some time: in the case of learning anything, this persistence will count in stamping the impression; and part of the effect of a lesson must be lost in hurrying without a moment's break to something new, even although the change of subject was of the nature of relief. By his own account, his lessons at Toulouse, with the exception of French and music, took no effect upon him. Nor is this the worst feature of Mill's programme. According to our present notions of physical and mental training, he ought to have had a decided break in the afternoon. Considering that he was at work from about six in the morning, with only half an hour for breakfast, he should clearly have had, between one and two, a cessation of several hours, extending over dinner; especially as

he gave up the evening to his hardest subjects. Of course this interval should have been devoted to out-of-doors recreation. It is quite true that both father and son were alive to the necessity of walking, and practiced it even to excess; in fact, counted too much upon it as a means of renewing the forces of the brain: their walks were merely a part of their working-day—a hearing and giving of lessons.

What with his own recital in the "Autobiography" and the minuter details in the letter to Sir S. Bentham, and the diary, we have a complete account of his reading and study in every form. The amount is, of course, stupendous for a child. The choice and the sequence of books and subjects suggest various reflections. His beginning Greek at so early an age was no doubt due to his father's strong predilection for the language. What we wonder at most is the order of his reading. Before his eighth year, he had read not merely the easier writers, but six dialogues of Plato (the Theætetus he admits he did not understand). He was only eight when he first read Thucydides, as well as a number of plays. At nine he read parts of Demosthenes; at eleven he read Thucydides the second time. What his reading of Thucydides could be at eight, we may dimly imagine: it could be nothing but an exercise in the Greek language; and the same remark must be applicable to the great mass of his early reading both in Greek and Latin. At Toulouse we find him still reading Virgil, of although five years before he had read the Bucolics and six books the Æneid. Moreover, at Toulouse, his Greek reading was Lucian, a very easy writer whom he had begun before he was eight; the noticeable fact being that he is now taking an interest in the writer's thoughts and able to criticise him. It is apparent enough that his vast early reading was too rapid, and as a consequence superficial. It is noticeable how rare is his avowal of interest in the subjects of the classical books; Lucian is an exception; Quintilian is another. He was set by his father to make an analysis of Aristotle's Rhetoric and Organon, and doubtless his mind was cast for Logic from the first. His inaptitude for the matter of the Greek and Latin poets is unambiguously shown; he read Homer in Greek, but his interest was awakened only by Pope's translation. His readings in the English poets for the most part made no impression upon him whatever. He had a boyish delight in action, battles, heroism, and energy; and, seeing that whatever he felt, he felt intensely, his devotion to that kind of literature was very ardent. But whether from early habits, or from native peculiarity, he had all his life an extraordinary power of *re*reading books. His first reading merely skimmed the subject; if a book pleased him, and he wished to study it, he read it two or three times, not after an interval, but immediately. I can not but think that in this practice there is a waste of power.

It was impossible for his father to test the adequacy of his study of Greek and Latin works, except in select cases; and hence it must have

been very slovenly. In Mathematics, he had little or no assistance, but in it there are self-acting tests. His readings in Physical Science were also untutored: unless at Montpellier, he never had any masters, and hisknowledge never came to maturity.

If I were to compare him in his fifteenth year with the most intellectual youth that I have ever known, or heard or read about, I would say that his attainments on the whole are not unparalleled, although, I admit, very rare. His classical knowledge, such as it was, could easily be forced upon a clever youth at that age. The Mathematics could not be so easily commanded. The best mathematicians have seldom been capable of beginning Euclid at eight or nine,[1] and even granting that in this, as in other subjects, he made small way at first, yet the Toulouse diary shows us what he could do at fourteen; and I should be curious to know whether Herschel, De Morgan, or Airy could have done as much. I have little doubt that, with forcing, these men would all have equaled him in his Classics and Mathematics combined. The one thing, in my judgment, where Mill was most markedly in advance of his years, was Logic. It was not merely that he had read treatises on the Formal Logic, as well as Hobbes's "Computatio sive Logica," but that he was able to chop Logic with his father in regard to the foundations and demonstrations of Geometry. I have never known a similar case of precocity. We must remember, however, that while his father pretended to teach him everything, yet, in point of fact, there were a few things that he could and did teach effectually: one of these was Logic; the others were Political Economy, Historical Philosophy and Politics, all which were eminently his own subjects. On these John was a truly precocious youth; his innate aptitudes, which must have been great, received the utmost stimulation that it was possible to apply. His father put enormous stress upon Logic, even in the scholastic garb; but he was himself far more of a logician than the writers of any of the manuals. In that war against vague, ambiguous, flimsy, unanalyzed words and phrases, carried on alike by Bentham and by himself, in the wide domains of Politics and Ethics, he put forth a faculty not imparted by the scholastic Logic; and in this higher training the son was early and persistently indoctrinated. To this were added other parts of logical discipline which may also be called unwritten: as for example, the weighing and balancing of arguments *pro* and *con* in every question; the looking out for snares and fallacies of a much wider compass than those set down in the common manuals. (See the beginning of the "Bentham" article for Mill's delineation of Bentham's "Logic.")

He returned to England in July, 1821, after a stay of fourteen months. He sufficiently describes the fruits of his stay in France, which included a familiar knowledge of the French language, and acquaintance with

[1] Locke knew a young gentleman who could demonstrate several propositions in Euclid *before he was thirteen.*

ordinary French literature. If we may judge from what he says afterward, his acquaintance with the literature was strictly *ordinary;* he knew nothing of the French Revolution, and it was at a much later period that he studied French authors for the improvement of his style.

He had still nearly two years before entering on official life; and he tells us how these were occupied. His father had become acquainted with John Austin, who assisted him in Roman Law, his destination being the bar. He also got deep into Bentham for the first time, and began Psychology. He now read the history of the French Revolution. An undated letter to his father probably belongs to this period. He was on a visit to Mr. and Mrs. Austin at Norwich. The letter begins with a short account of his studies. He read Blackstone (with Mr. Austin) three or four hours daily and a portion of Bentham's "Introduction" (I suppose the Morals and Legislation) in the evening. Among other things, "I have found time to write the defense of Pericles in answer to the accusation which you have with you. I have also found some time to practice the delivery of the accusation, according to your directions." Then follows an account of a visit of ten days with the Austins to the town of Yarmouth, with a description of the place itself. The larger part of the letter is on the politics of Norwich, where "the Cause" (Liberal) prospers ill, being still worse at Yarmouth. He has seen of Radicals many; of clear-headed men not one. The best is Sir Thomas Beever, whom he wishes to be induced to come to London and see his father and Mr. Grote. At Falmouth he had dined with Radical Palmer, who had opened the borough to the Whigs; not much better than a mere Radical. "I have been much entertained by a sermon of Mr. Madge, admirable as against Calvinists and Catholics, but the weakness of which as against anybody else I think he himself must have felt." The concluding paragraph of the letter should have been a postscript:

> I wish I had nothing else to tell you, but I must inform you that I have lost my watch. It was lost while I was out of doors, but it is impossible that it should have been stolen from my pocket. It must therefore be my own fault. The loss itself (though I am conscious that I must remain without a watch till I can buy one for myself) is to me not great—much less so than my carelessness deserves. It must however vex you—and deservedly, from the bad sign which it affords of me.

On his return from France, he resumed energetically the task of home teaching; making a great improvement in the lot of his pupils, who were exclusively under their father's care in the interval; for while he scolded them freely for their stupidity and backwardness, he took pains to explain their lessons, which their father never did. He was kept at this work ever after. I remember on one occasion hearing from Mrs. Grote that she had turned up an old letter from James Mill, in answer to an invitation to John to accompany Mr. Grote and her on a

vacation tour; the reply was that he could not be spared from the work of teaching the younger children.

The "Autobiography" gives a full account of his acquaintances among the young men resident at Cambridge, who afterward came to London, including, besides Charles Austin, who was the means of introducing him, Macaulay, Hyde and Charles Villiers, Strutt (Lord Belper), Romilly, etc. There is no mention of his having gone to Cambridge in 1822, on a visit to Charles Austin. The contrast of his boyish figure, and thin voice, with his immense conversational power, left a deep impression on the undergraduates of the time, notwithstanding their being familiar with Macaulay and Austin.

I alluded, in my last article on James Mill, to the persistent attempts of Professor Townshend, of Cambridge, to get John entered there. Here are two sentences from a letter dated March 29, 1823, two months before he entered the India House: "I again entreat you to permit me to write to the tutor at Trinity to enter your son's name at that noble college. Whatever you may wish his eventual destiny to be, his prosperity in life can not be retarded, but must on the contrary be increased by making an acquaintance at an English University with his Patrician contemporaries." Whether it would have been possible to induce his father to send him to Cambridge, I very much doubt. I suspect that, of the two, the son would have been the more intractable on the matter of subscription to the Articles. Ten years later, it was an open question in the house whether his brother Henry should be sent to Cambridge.

THE INTRA-MERCURIAL PLANETS.[1]

By CAMILLE FLAMMARION.

A GOOD deal of noise was made a few months ago about a discovery that an American astronomer believed he had made during the recent solar eclipse of July 29, 1878. At the moment of totality, while the bright disk of the sun was completely hidden by the black disk of the moon, and after the eye had become habituated to this sudden darkness, the American astronomer made a search to find whether there might not be, in the vicinity of the sun, a planet answering to the theoretical planet Vulcan, whose existence was announced by Leverrier after he had mathematically analyzed the motion of Mercury. As every one knows, during total eclipses of the sun, our atmosphere being no longer illumined, night comes on as though at the bidding of an enchanter, and the brighter stars make their appearance in the heavens. It is this sudden metamorphosis of nature that most forcibly impresses

[1] Translated from "La Nature" by J. Fitzgerald, A. M.

primitive races; it was this which, on the occasion of the earliest eclipse recorded in history—the eclipse of Thales—put a stop to the famous war of the Medes and the Persians, by sending the chill of mortal terror into the hearts of the warriors as they were on the point of engaging in battle; this it was which, at the last eclipse, led a negro, suddenly frenzied and convinced that a deluge was about to be sent down by an angered Deity, to strangle his own wife and children; finally, it is this same feature of the solar eclipse which makes the deepest impression on the mind of the astronomer who has made all his preparations for observation, but is so full of emotion in view of the grandeur of the spectacle, that he can only with difficulty analyze with his wonted coolness, and during the few minutes of total darkness, the details of the phenomenon.

The American astronomer Professor Watson, the discoverer of a great number of small planets, has declared that his one thought during the recent eclipse was to look for the intra-Mercurial planet. In announcing this observation to the Academy of Sciences, the Director of the Paris Observatory, M. Mouchez, expressed himself thus:

The accomplished astronomer of Ann Arbor has seen a heavenly body of the fourth magnitude, situated two degrees distant from the sun, and whose position was: right ascension, $8^{h.}$ $26^{m.}$; declination north, 18° 0′.

The star nearest to this position is Theta Cancri ($8^{h.}$ $24^{m.}$ and 18° 30′), and it is of the fifth magnitude. This difference of magnitude and of position justifies us in supposing that in all probability it was the planet Vulcan which was again seen by Mr. Watson. The Academy can not but receive with great pleasure this observation, which is only a new tribute to the scientific glory of Leverrier. M. Gaillot has calculated an orbit and an ephemeris. The time of revolution is only twenty-four days. The planet is at its greatest distance from the sun to-day (August 5th); to-morrow it will be at thirty-eight minutes of time. This distance is great enough to allow of our observing it, if not at Paris, at least at other more favored localities.

Watson's own account of the observation is as follows:

At the recent total eclipse of the sun I was occupied exclusively in a search for any intra-Mercurial planet which might be visible. For this purpose I employed an excellent four-inch refractor, by Alvan Clark & Sons, mounted equatorially with a magnifying power of forty-five. There were no circles originally attached to the instrument, and accordingly I placed on it circles of hard wood, the declination circle being five inches and the hour circle four and three quarter inches in diameter. On these I pasted circles of cardboard, and pointers were provided so that I could mark with a sharp pencil the position corresponding to any particular pointing of the instrument. This method does not compare in accuracy with graduated circles and veniers, but it has the advantage, and a very important one in the present case, of avoiding the uncertainty which might be attributed to erroneous readings of the circles. To read the divided circles would require considerable time, while the pointings can be marked on the paper disks in a few moments. And, besides, while a doubt might be raised as to the correctness of the recorded circle readings, no such doubt can exist in reference to the positions marked on these paper circles. The chronometer

times corresponding to each pointing were recorded, and the designation of the object observed was also marked on the paper disks, so that there is no difficulty in identifying the several marks.

He then goes on to give the particulars of his sweeps over the regions east and west of the sun, which were without result till, at last—

Between the sun and θ Cancri . . . I came across a star estimated at the time to be of four and a half magnitude, which shone with a ruddy light and certainly had a larger disk than the spurious disk of a star. The focus of the eye-piece had been carefully adjusted beforehand and securely clamped, and the definition was excellent. I proceeded, therefore, to mark its position on the paper circles, and to record the time of observation. It was designated by a. The place of the sun had been recorded a few minutes previously, and marked S_1. Placing my eye again at the telescope, I assured myself that it had not been disturbed, and proceeded with the search. I noticed particularly that the object in question did not present any elongation such as would be probable were it a comet in that position.

This body he holds to be Leverrier's intra-Mercurial planet. Its place is given as follows: $8^{h.}\ 26^{m.}\ 24^{s.}$; declination 18° 16′. It will be seen that this position differs from that given above, the declination being here 18° 16′, instead of 18° 0′.

On August 23d the observer added a new correction: "In consequence of having employed an inexact value for the correction of the chronometer, an error has crept into the results. The true position is this: right ascension, $8^{h.}\ 27^{m.}\ 35^{s.}$; declination, 18° 16′."

Here we have a fresh difference in the first figure. The result is, first, that the orbit calculated immediately upon receipt of the telegram was made too hastily and on an insufficient basis.

According to the American observer, the definitive differences between the planet and the sun were: in right ascension, $8^{m.}\ 21^{s.}$; in declination, 0° 22′. But in this same letter of August 23d he announces that he observed another star, also of the fourth magnitude, which presented the following differences from the sun: in right ascension, $27^{m.}\ 18^{s.}$; in declination, 0° 35′. Whence results for this second star the position: right ascension, $8^{h.}\ 8^{m.}\ 38^{s.}$; declination, 18° 3′.

A fourth datum sent to the London Royal Astronomical Society again corrects these positions as follows:

$$8^{h.}\ 27^{m.}\ 24^{s.}\ +\ 18°\ 16'$$
$$8^{h.}\ \ 9^{m.}\ 24^{s.}\ +\ 18°\ \ 3'$$

We will remind our readers that the right ascension of a star is its distance east or west from the first point of Aries, measured along the celestial equator, and its declination is its distance above or below that equator. They are the longitudes and latitudes of the heavens, corresponding to those of earth, and they serve to determine the positions of stars as earth longitudes and latitudes serve to fix in geography the exact positions of cities.

And now comes another American astronomer, Mr. Swift, who also announces that during the same total eclipse he observed simultaneously in the field of his telescope two stars, of which the one was Theta Cancri, and the other a planet shining with the luster of a star of the fifth magnitude, and whose position he estimates approximately to be, right ascension $8^{h.}$ $26^{m.}$ $40^{s.}$, declination $+ 18° 30' 35''$, a position very near to that of the star seen and determined by Mr. Watson.

The eclipse of July 29th last, one of the most remarkable of the present century for the duration of totality, was observed all along the zone of centrality (which passed across North America), by a great number of able astronomers, both American and English. Nearly all of these searched for a new star in the neighborhood of the sun, but, with the exception of the two named above, all declare that they saw nothing beyond the stars rendered momentarily visible by the obscuration of the sun's light.

Are we thence to conclude that the testimony of these two observers must be rejected? By no means. But between this and the conclusion that the two stars signalized by Watson are in fact two planets traveling between Mercury and the sun, is a long way. Of these two stars, the second, it is supposed, can not be the star Zeta Cancri, whose position is $8^{h.}$ $5^{m.}$ $12^{s.}$ and $18° 2'$.

The difference of three minutes is no doubt very great, but when we take account of the haste of observation, and the doubt expressed by the observer himself with regard to its exactness and the possible derangement of his telescope by the action of the wind, this star must not be dismissed without seeing whether or not it will explain the observations. Now, supposing an error of three minutes more or less, the position of the first star becomes $8^{h.}$ $24^{m.}$ and $18° 16'$, and this is very nearly the position of the star Theta Cancri.

All that is needed to show how probable is this explanation is to take up a celestial atlas and to locate the sun at the point where it was at the moment of the eclipse, i. e., in front of Delta Cancri (which was visible through the aureolar corona of the eclipsed sun, at its eastern margin).

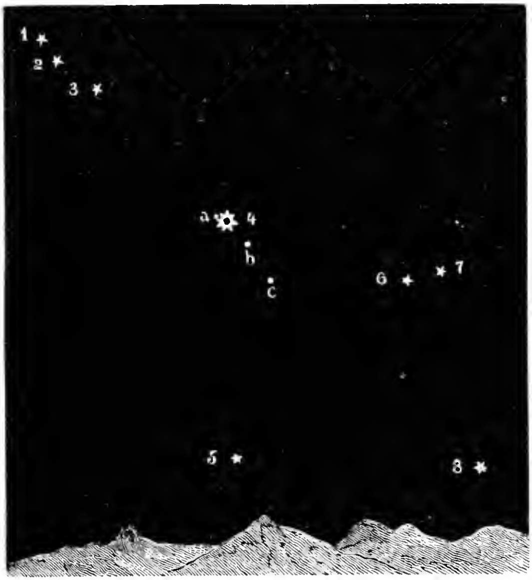
We have reproduced in the figure the aspect of the heavens during totality.

1 is Mercury,	5 is Procyon,
2 is Regulus,	6 is Pollux,
3 is Mars,	7 is Castor,
4 is the sun in eclipse,	8 is Venus.

In the immediate vicinity of the sun we have inserted at the points *a*, *b*, *c*, the three stars Delta, Theta, and Zeta Cancri. In our opinion the two stars *b* and *c* are the ones which might have been taken for two planets by the American observers. No doubt this hypothesis is a rather bold one, but then the hastiness, the difficulty, and the vagueness of the observation justify it.

Mr. Watson did not announce his observation of the second star till three weeks after the eclipse, and after he had revised in detail the conditions of his observation. Here is proof that this star had made a less impression on him than the first. But now the first is between the fourth and fifth magnitudes, and the second only between the fifth and the sixth.

In any case, we can not but hold that the positions given are highly doubtful and can not be seriously assumed as a basis for calculating orbits, as has been done at the observatory.



Mr. Swift writes, "I have no doubt that one of the two stars was Theta Cancri, and the other the intra-Mercurial planet."

But if one of the two stars seen by Professor Watson is Theta Cancri, the other, whose difference from the former is, according to him, $18^{m.}\ 57^{s.}$ more to the west, and 13′ more to the south, comes exceedingly near to Zeta Cancri, whose difference from Theta is $19^{m.}\ 25^{s.}$ also to the west, and 30′ also to the south. If this star were a planet it would not have been possible to see it without at the same time seeing Zeta, which would have been quite near; but of Zeta our American astronomers do not speak.

Mr. Swift, however, answers this objection by saying that he saw simultaneously Theta and the planet, and states the difference between them as follows:

	Right ascension.	Declination.
Star Theta,	$8^{h.}\ 24^{m.}\ 40^{s.}$	$+\ 18°\ 30'\ 20''$
Planet,	$8^{h.}\ 26^{m.}\ 40^{s.}$	$+\ 18°\ 30'\ 25''$

The two stars appeared red to him, shining at three degrees southwest of the sun, and presenting large disks of the fifth magnitude. He adds that he saw no other star, not even Delta, and that the distance between them was from 7′ to 8′ of arc. ("Nature," September 19, 1878.)

The two stars seen by Swift, then, are not the same two seen by Watson. The matter is a good deal confused.

Further, in observing the star Zeta Cancri, two stars could have been seen, instead of one, for Zeta is a double star. It is, indeed, a triple star, but a high power is required to see it triple, whereas a moderate power easily shows it double. But, inasmuch as only very low powers were employed, it is probable that no new cause of perplexity exists here.

To sum up : While it is possible that the American observers saw an intra-Mercurial planet, or even two, we can not, in view of the special difficulties of the situation, the confusion of the figures, and the negative observations of the other observers, concede it to be an absolute and incontestable fact that they saw even so much as one. The fact is not yet *certain.*

We would remark that no variable star is known to exist at that part of the heaven. Might it not be a comet? It did not present the characteristics of a comet.

Whatever the upshot may be, this discussion goes to show that in astronomy nothing is accepted without being first verified, and that this science is becoming more and more worthy of its reputation of being the exactest and the most absolute form of human knowledge.

This strange vicinage of the sun is unfortunate indeed in the annals of astronomy. Time and again have observers supposed that they saw planets passing before the sun ; and, out of all the observations which have been made, there is not one which definitively settles the question.

The penultimate astronomical observation announced as appertaining to an intra-Mercurial planet was that of the German astronomer Weber, which was presented to Leverrier by Wolf, of Zurich, as having been made April 4, 1876, at Peckeloh. "A small, well-rounded disk of 12″ of arc appeared suddenly during a partial clearness of the sky (*éclaircie*), which was turned to account for observing the sun. It was impossible to pursue the observation, owing to clouds." Wolf calculated that this observation accorded with two prior observations made in 1859 and in 1820, and fixed the period of the planet at forty-two days. Leverrier, too, seemed disposed to accept this observation, which gave occasion for a new memoir by the illustrious French astronomer, in which he brought together and compared all the observations of this kind. The stir which this made in the scientific periodicals is still remembered. But yet the little black disk observed by Weber was not a planet at all, but merely a sun-spot, round and without penumbra. It had been observed five hours earlier at the Observatory of Madrid and at the Observatory

of Greenwich, and it was easy to prove that it was nothing but a simple sun-spot.

The fact that the spot was not to be seen the next day seemed to confirm the planetary hypothesis; but it was not sufficient, since there are ephemeral sun-spots, too. Nor is the roundness of the spot a distinctive character either. The proper movement then remains. Here we must note a circumstance which oftentimes must have caused illusions. When we observe the sun with a telescope not equatorially mounted, and whose support has not the two motions, vertical and azimuthal, as is commonly the case, the position of a sun-spot, by reason of the diurnal motion, is ever changing with relation to the vertical diameter of the disk. Even when an observer has had large experience, it is difficult for him to guard against the belief that the spot has changed its position on the disk.

This observation, then, had to be disallowed. But there remained others which were not to be discredited on the same grounds, and Leverrier, taking them to be more trustworthy, used them in calculating the orbit of the hypothetical planet. Different interpretations gave him five different orbits, with periods varying between twenty-four and fifty-one days. But he seems to have preferred that which gives a period of thirty-three days, and announced that on March 22, 1877, the planet in question might pass before the sun. Astronomers all over the world, with one accord, observed the sun on that day, to descry the transit, but the result was *nil.* No black point was to be seen.

Among the prior observations Leverrier accepts five as certain, viz.: Fritsche's, in 1802; Stark's, in 1819; Cuppis's, in 1839; Sidebotham's, in 1849; Lescarbault's, in 1859; Lumnis's, in 1862. One of the best is no doubt that of Dr. Lescarbault, a country doctor, with a passion for astronomy, and who had vowed to the study of the heavens the time which was not spent in alleviating the wretchedness of earth.

This amateur astronomer, while observing the sun on March 26, 1859, from his humble house at Orgères, discovered on its radiant disk a round, very black spot, which he was able to study for over an hour, and the proper motion of which he thus determined, no doubt taking account of the causes of error to which we have alluded. It was during this same year that Leverrier perceived the necessity of increasing by 38″ the secular movement of Mercury's perihelion, and offered the hypothesis that a planet nearer to the sun than Mercury would account for the difference. Thus the observation made by my old and learned friend came as though on purpose to confirm the theory, just as earlier the telescopic discovery of Neptune had come to confirm so brilliantly the theoretical discovery of that distant planet.

Wellnigh twenty years have passed since 1859, and yet a fact which one might have supposed would be speedily confirmed, owing to the rapidity of the planet's revolution, and its no doubt frequent transits across the sun—this fact has received no confirmation. Yet search

has been made for it throughout the whole region on both sides of the sun, if perchance it might be seen at the periods of its greatest distance. Perhaps not a day has passed for the last twenty years, but that the sun has been examined at one point or another of the globe, observed with the greatest care, sketched in all its details, even directly photographed.

The hypothesis of a single body comparable to Mercury, gravitating in close proximity to the sun, and on a plane probably little inclined to the solar equator, seems to us to be so open to objections as to be untenable. Still, the mathematical theory of universal attraction proves that there is a cause for the retardation observed in the motion of Mercury, and that this cause can not be found by augmenting the mass of Venus —a quantity now determined with great exactitude—but must be sought for in some disturbing mass between Mercury and the sun. But this mass may not be a planet worthy of the name of planet; it may consist of a great number of asteroids like the minute fragments which gravitate between Mars and Jupiter—asteroids so small that oftentimes they escape the notice of observers of the sun and of eclipses, though some of them may be large enough to be seen under certain rare conditions. This latter theory is the one which we adopt.

DIETETIC CURIOSITIES.

By FELIX L. OSWALD, Ph. D., M. D.

I.

"MAN is what he eats" (Der Mensch ist was er *isst*) is a German proverb, the propriety of which may be chiefly alliterative, though the apothegm of our greatest English physician goes even further: "If we could solve the problem of diet," Dr. Radcliffe tells us, "it would almost amount to the rediscovery of paradise. Wrong eating and drinking, and the breathing of vitiated air (which is gaseous food), these form the triple fountain-head of nearly all our diseases and our misery."

Even a great doctor is fallible, especially on his hobby, but it is not easy to deny the importance of a subject which can assert itself by such dire *argumenta ad hominem* as dyspepsia, congestive chills, and other penalties that follow swifter now than in old times on any violation of the physical laws of God. Love of health or fear of sickness (which differ as ancient from modern civilization) has always made the question of diet one of primary interest; yet there is certainly none about which doctors disagree more widely. It is amusing to compare the different food-theories which have been cherished like plans of salvation

since the fighting of un-nature first became a science. If contradictory tenets imply error, we surely are further from unitary truth here than anywhere except in the Babel of speculative theology; and even there only dogmatic assertion, but not inconsistency, could ever go further. Just compare the gospel of Pythagoras with that of Dr. Brown, the Berwick prophet. Abstinence from wine—alcoholic stimulants, we would say at present—and from all animal food is the keystone of the Pythagorean system, which also denounced the shedding of blood, and recommended the use of "food which needs no cooking"—fruit, nuts, honey, milk, and the like. But John H. Brown, M. D., divides all possible states of health into the "sthenic and asthenic conditions," the first to be toned down by bleeding, cathartics, etc., the second to be rallied by a liberal use of brandy and strong meats, which in more moderate quantities are to constitute our normal food, while all raw vegetable products are to be avoided, especially "acid and subacid fruit."

Is there a greater antagonism in all the *toto-cœlo* distance from Odin to Mother Ann Lee? If either was right, the other must have been portentously wrong; yet the school of Berwick, not less than that of Samos, counted its disciples by tens of thousands. Again, is there an hygienic tenet which seems more incontrovertible to us than the propriety of the three daily meals? Yet the Romans of the ante-Cæsarean era, who as physical beings were so strangely superior to us, restricted themselves to a single meal in the twenty-four hours, for which they chose the very time when we dread repletion most—the end of the day, the hour between sunset and darkness.

Moses transmits from the lips of Jehovah his by-laws against pork and rabbit-flesh, and we know how many of his followers preferred death to the obnoxious diet, but our Saxon forefathers exalted the pigs' feet of Valhalla as the supreme reward of heroic virtue, and, dying, the Baresark could grin through his tortures at the thought of celestial spareribs. Charlemagne, when informed that his life depended on a change of *régime*, declared that if he could purchase immortality by absenting himself from the customary tri-weekly barbecues, he would think the price too high. He may have doubted the efficacy of the sacrifice, but the Mingrelian ambassadors, after receiving Abu-Hassan's stern ultimatum, "Islam or the sword!" informed him that, however willing they might be to propitiate the wrath of Allah, the national assembly preferred war and pork to peace without it.

Thales considered water as the *summum bonum*, and many of his teachings seem to anticipate the hydropathic school and our temperance dogmas; but Paracelsus proclaimed to the world that he had found the true panacea and the elixir of life by the discovery of alcohol, and seems to have been only too successful in his propaganda. "He finds believers who himself believes"; and Paracelsus certainly proved personal confidence in his doctrine by swallowing (in the city of Salzburg, 1541), as the "grand quintessence of life," a five-pint bottle of alcohol,

which it had taken him two months to distill. The funeral was very impressive, as the Salzburg chronicle thinks it necessary to observe. We know that our North American Indians are purely carnivorous, and persistently neglect all opportunities of enlarging their *menu;* also, that white men who voluntarily or otherwise shared their fortune and potluck for a few years, refused to rejoin Caucasia afterward. Similar stories were told in ancient Greece of the Lotophagi (lotus-eaters), a people of peculiar habits, who boasted that any stranger living among them for a little while would rather resign kinsmen and country than leave them again, only with this difference: the magnetism and the name of the Lotophagi were derived from their diet of lotus-leaves—they were strict vegetarians.

With every allowance for a possible diversity of constitutions, generic differences, and the modifying influence of climate, the subject still presents enigmas which almost force upon us the conclusion so fiercely rejected by Jean Jacques Rousseau, that nature and habit are interchangeable terms. Two hundred million Hindoos abstain from the use of animal food, by behest of Vishnu, as they say; by necessity of climate, as we explain it. But the inhabitants of Southern Africa, in defiance of Vishnu and climate, gorge themselves with meat as often as they can procure it, and with perfect impunity, it seems.

"Meat," says Professor von Liebig, "is preëminently the muscle-forming food; hence the difference between the stout Briton and the lean Spaniard, the delicate Hindoo and the robust Ethiopian." But the Lesghian mountaineers and the box-carriers of Constantinople, though not vegetarians by principle, subsist chiefly on fruit and farinaceous food, and it so happens that every other man of them can shoulder a load that would task the combined strength of the stout Briton and robust Ethiopian. The powerful arms and the ponderous, leonine bearing of the occasional Turks who visit the fairs of Vienna and Buda-Pesth are a fine practical argument in favor of temperate habits; yet their rivals in strength, the iron-fisted Bauern of Upper Austria and the Bavarian highlands, are notorious for their abject worship of beer.

But, for all that, it would be wrong to abandon the hope of rediscovering paradise by Dr. Radcliffe's road. Whatever may be the right way, we can not afford to swerve from it, least of all consciously, and that we are astray at present is most distressingly probable. Dr. Boerhaave reminds us that there are certain maxims of health, so clearly pointed out by *a priori reasoning*, that we can not be too cautious in the acceptance of contradictory evidence.

"For instance, the exceptional cases of robust health in conjunction with habits denounced as injurious by all analogy ought to make us inquire how this impunity is earned; which strong protector of health could overcome such an enemy. For there is such a thing as *vicarious atonement* in physiology. Athletic sports, fatiguing rides on horseback, and any long-continued exercise in open air, seem to grant a long im-

munity from the effects of vicious diet; and it seems that there is a peptic stimulus in mountain air and the climate of a high latitude."

The kitchen-reformers of England and North America seem united on the question of alcohol only, but contradict each other and sometimes themselves in their food-theories and general toxicology. The hygienic system of Dio Lewis embraces the vegetarian, total abstinence, and hydropathic dogmas, but in consistent logic and ingenuity is far surpassed by that of Schrodt, the Swiss dietist.

In his "Natur-Heilkunde," Schrodt distinguishes between natural, artificially adapted, and unnatural or wholly injurious articles of food. "Our natural food," he says (like Pythagoras), "are such vegetable and semi-animal products *as either are or can be eaten and relished raw, and without the preliminaries of cooking and spicing.* Such are milk, honey, eggs, nuts, cereals, a few roots, legumina, and gums, and the countless variety of fruit, which are man-food *par excellence.* Our various kinds of bread, though artificially prepared, as well as other farinaceous dishes, are derived from an edible grain which is neither repulsive nor indigestible in its original state.

"To the second or adapted edibles belong different vegetables which are rendered palatable only by the process of cooking, as cabbage, beans, peas and lentils, and various roots and leaves. Flesh, also, I will add to this list, though some would place it in the third class. Injurious, without a redeeming quality, are all narcotic and alcoholic drinks, and all ardent spices, such as pepper, mustard, and acid fluids; also those partly decayed and acid substances whose properties are more stimulating than nourishing: strong cheese, sauerkraut, and pickles."

This system is based on the idea that an unvitiated taste is a sufficient criterion of healthfulness in food, and that to the palate of a child all wholesome substances are agreeable, all injurious ones repulsive. "A taste for the so-called articles of diet embraced in my third class," says Herr Schrodt, "is always *artificially and painfully acquired.* No man of veracity or memory will tell me that he liked cheese or brandy at first." In accounting for the prevalence of stimulation and intemperance among seemingly healthy nations, he too falls back on vicarious atonement by otherwise salutary habits.

Viewed in the light of Dr. Boerhaave's theory, the gastronomic exploits of ancient and modern savages may gain an additional interest. How desirable it would be to know by which vicarious virtue his Majesty the Emperor Vitellius could atone for the often-repeated sin of devouring three brace of peacocks at a sitting, which Suetonius assures us did not prevent him from appearing in the palestra an hour afterward and joining in the games which were prolonged by torchlight toward the morning hour! Vendôme, the champion of France and the one strategic peer ever opposed to Marlborough, was as formidable at the mess-table as on the battle-field. He would gorge himself till his joints

commenced to tremble and the oppression of his chest threatened him with asphyxia. Woe to the waiter or messmate who offended him by word or want of attention in such moments! A fierce blow, a hurled tumbler, or a tremendous kick were the mildest expressions of his impatience. After the defeat of Oudenarde he saved the French army by a masterly retreat that kept him in the saddle for two days and two nights, and then restored himself, not by sleep, but by sitting down to a banquet of sixteen hours, during which he incorporated as many pounds of mutton-pie, if we may believe Chateaubriand.

Calmucks, according to Mr. Schuyler, will travel a hundred miles to stuff themselves with horseflesh at somebody else's expense; and Gordon Cumming mentions a family of Zulu-Caffres—a man, two wives, and four children—who, between noon and sunset, disposed of all the meat, marrow, and intestines of a large zebra, and during the following night picked the bones in a way which only an army of ants could emulate. Vambéry speaks of a Tartar courier, named Thuy-Kasr, who boasted of having eaten, "unassisted and without employment of witchcraft," a large skinful of raisins and a middle-sized pig, leaving nothing but bristles and a few of the larger bones; and once, within fifty hours, even a goat with two kids, together with a bag of dried figs and deep potions of *koumiss* or fermented mare's milk. Thuy-Kasr must have known the secret of Apicius, "which enabled the adept to prolong his appetite for two days and a night." But such Tartars are not the exclusive product of Central Asia. James Halpin, a Yorkshire man, who exhibited himself in Manchester and other English cities during the first years of this century, thought nothing of eating a dozen pigeons, bones, feathers and all; swallowed trout and larger fishes alive, and won a wager by devouring within two hours all the edibles, including half a cheese and a large quantity of pickles, on a table that had been set for eight persons!

Joseph Kolnicker, born 1809 in Passau, southern Germany, who served as a private soldier for a couple of years, had to be discharged before the expiration of his term on account of his appalling appetite. He would devour raw potatoes, horse-turnips, cabbages in the garden, could empty basketfuls of eggs in a few minutes, and, in spite of all precautions, gained admittance to an officer's pantry or the commissary storerooms now and then, and with most deplorable results. He, too, converted his expensive talent into a source of profit by public exhibitions, and won so many incredible bets that, much to his regret, his renown eventually spread like that of the athlete Milo, and nobody dared to challenge him.

But no modern virtuoso can emulate the giants of antiquity. Claudius, Caligula, Domitian, and Heliogabalus, the imperial gluttons, almost exhausted the resources of the Orbis Romanus by their monstrous voracity. Cicero compares the scene after a Roman banquet to a battle-field; and many of the wealthiest patricians were ruined by one or two

of those entertainments, to which the above-named potentates had an unpleasant habit of inviting themselves.

The symposia of Apicius lasted from twenty to thirty hours, and his semi-annual state dinners even two days, during which host and guests were restricted to recesses of ten minutes, and etiquette required them to partake of every dish and drink, the quantity being optional, except in regard to certain spiced wines, of which a good-sized jug was *de rigueur*—a rule which could only be circumvented by liberal libations to the gods. Yet even excess itself was exceeded by the mania of Vitellius, who wasted the yearly revenue of a province on a single banquet, gorged himself for hour after hour without intermission, and, in the words of Tacitus, "unadmonished by the eruptive protests of nature, never thought of yielding while he could see and hear"! He and some of his successors on the throne of gluttony probably owed their immunity to the virtues of a long lineage of frugal ancestors. Italy, truly, is the land of contrasts, of extremes in virtue as well as in vice. The resources wasted on a single day at one of those saturnalia of intemperance would probably have fed a village for a century of the early republican era, and for at least twenty years in our present time of poverty-born frugality. Frugal, in its original sense, meant literally subsisting on fruit in distinction to carnivorous habits, which were thought extravagant. Cyrus, King of Persia, according to Xenophon, was brought up on a diet of water, bread, and cresses, till up to his fifteenth year, when honey and raisins were added; and the family names of the Fabii and Lentuli were derived from their customary and possibly exclusive diet. Eggs and apples, with a little bread, were for centuries the alpha and omega of a Roman dinner; and, in earlier times, even bread and turnips, if not turnips alone, which the patriot Cincinnatus thought sufficient for his wants. It is singular that our temperance societies direct their efforts only against the fluid part of our vicious diet; a league of temperate eaters would certainly find a large field for reform. But in Italy the thing was attempted by Luigi de Cornaro, a Venetian nobleman of the fifteenth century, who restricted himself to a daily allowance of ten ounces of solid food and six ounces of wine, and prolonged his life to one hundred and two years. Though he did not organize his followers into a sect, his example and his voluminous writings influenced the manners of his country for many years. Cornaro would not have gained many converts in Russia and Germany; but throughout southern Europe frugality, in the truest old Latin sense, is by no means rare. Lacour, a Marseilles 'longshoreman, earned from ten to twenty francs a day, loaned money on interest and gave alms, but slept at night in his basket, and subsisted on fourteen onions a day, which preserved him in excellent health and humor, but got him the nickname of *quatorze oignons*.

A pound of bread with six ounces of poor cheese, and such berries as the roadside may offer, constitute the daily ration of the Turkish

soldier on the march, and the followers of Don Carlos contented themselves with even less. A correspondent of the "Daily News" was served with a dish of radishes in a Catalan tavern, and ventured the remark that radishes were taken after meals in northern Europe. "You can get some more after finishing these," was the reply. The radishes constituted the dinner.

Not that men *should*, but that they *can*, live on bread alone, is abundantly proved by the records of Old-World prisons. Silvio Pellico, the Italian patriot and martyr, subsisted for seven years on coarse rye-bread and water, which experience had taught him to prefer to the putrid pork-soup of his Austrian bastile. The prisoners of the Khedive were fed on rice and Indian corn, till the prayers of the French residents and his American officers induced him to sweeten their bitter lot by a weekly bottle of sakarra, or diluted molasses ; and I learn from an article in a French journal that some of these unfortunates, who had passed long years without any hint of sakarra, were forced by chronic bowel complaints to return to their old dry fare.

Fedor Darapski, born 1774 in Karskod near Praga, eastern Poland, was brought to the government of Novgorod in his twenty-second year as a conscript to the Russian army, and was soon after sentenced to death for mutiny and assault with intent to kill. The Empress Catharine, acting on a recommendation of the Governor of Novgorod, commuted his sentence to imprisonment for life, but ordered that on every anniversary of the deed (an attempt to kill his colonel) the convict should receive forty lashes and be kept on half rations for a week after; the full ration being two pounds of black bread and a jug of cold water. On these terms Darapski was boarded at the fortress of Kirilov till 1863, when at the approach of his ninetieth birthday he was again recommended to mercy and liberated by order of the present Czar.

Even the story of Nebuchadnezzar may be more than an allegory, as the wild berries, roots, and grass-seeds of the Assyrian valleys contained surely as much nourishment as sour rye-bread ; and who knows but grass itself might do for a while, since the Slavonian peasants often subsist for weeks at a time on sauerkraut and cabbage-soup?

Corsican farmers live all winter on dried fruit and *polenta* (chestnut-meal), and the Moors of mediæval Spain used to provision their fortified cities with chestnuts and olive-oil. During the siege of Lucknow the native soldiers asked that the little rice left be given to their British comrades; as for themselves, they could do with the *soup*, i. e., the water in which the rice had been boiled!

But the *ne plus ultra* of abstinence combined with robust strength is furnished in the record of Shamyl, the heroic Circassian, who for the last two years of the war that ended with his capture had nothing but water for his drink and roasted beechnuts for his food, and yet month after month defied the power of the Russian Empire in his na-

tive mountains, and repeatedly cut his way through the ranks of his would-be captors with the arm of a Hercules.

The philosophers of antiquity prided themselves on their frugal habits, which ranked next to godliness in their estimation, as expressed in the famous aphorism, "God needs nothing, and he is next to Him who can do with next to nothing"—whose material needs are the smallest. Primitive habits are certainly favorable to independence, especially in a genial climate, where a man is above the fear of tyranny and all social obligations, who like Shamyl can subsist on the spontaneous gifts of his mother Earth. "Do you know," Cyrus asked the ambassador of a luxurious potentate, "how invincible men are who can live on herbs and acorns?" If the Saracens had persisted in the simplicity of their fathers, the nineteenth century might see Moorish kingdoms in southern Europe, and Arabian science and fruit-gardens in the place of deserts and monkish besottedness. Cato needed no prophetic inspiration to predict the downfall of a city where a small fish could fetch a higher price than a fattened ox.

Lycurgus, the Spartan, makes the diet of his countrymen the subject of careful legislation, but seems to have feared excesses in quality rather than in quantity: as long as the black soup and other national dishes remained orthodox in regard to the prescribed simple ingredients, free indulgence of the most exacting appetites was not only permitted but encouraged. At the philosophic reunions of the Lyceum the bill of fare permitted a choice between dried figs and honey-water in addition to the wheat-bread, which could not be refused, and Greece was the model of early Roman institutions in this as well as in other respects. Fruit and bread-cakes, spiced with Attic salt and music, entertained the friends of Plato at those suppers of the gods of three or four hours, which Aristotle preferred to so many years on the throne of Persia; but the very next generation witnessed the drunken riots of Babylon and the general introduction of Persian manners and luxuries.

The ancients undoubtedly were our superiors in hygienic insight, but among the many judicious restrictions of their dietary regimens there are some that we must attribute to prejudice or leave utterly unaccounted for. The Mosaic interdiction of rabbit-flesh, wild swan, and finless fishes has been very learnedly explained as a necessary consequence of general laws, which had to include those animals for the sake of consistency; but what on earth or below earth could induce Pythagoras, the great philosopher, to prohibit the use of *beans*—nay, even denounce any contact with the shell, the leaves, or the roots of the poor plant as a dreadful pollution? Such was the stigma he had attached to the violation of this rule, we are told, that a body of soldiers from Magna Græcia, who all belonged to the Pythagorean sect, permitted themselves to be cut to pieces or captured rather than save themselves by crossing a bean-field!

The old proverb *de gustibus* can hardly prevent astonishment at the diversity of tastes. What would Pythagoras have said about our national dish of pork and beans, or what shall we say to explain the Japanese prejudice against milk, the Papuan's partiality for fat white caterpillars, or the *gliraria* that were attached to every decent household of imperial Rome? Athenæus describes a glirarium as a large brick structure, divided by wire partitions into small cells, from five hundred to two thousand of them; every cell the receptacle of a captive rat, which was fattened on husks, rotten fish, and other offal, till a further increase in bulk would make it difficult to extract the animal through the narrow door of its cage. The perfect specimens were then collected, stuffed with crushed figs, and served in a sauce of olive-oil at the banquets of wealthy patriots who preferred domestic delicacies to colonial imports. The Digger Indians of our Pacific slope rejoiced in the great locust-swarms of 1875 as in a gracious dispensation of the Great Spirit, and laid in a store of dried locust-powder for years to come. Even mineral substances and strong mineral poisons have their votaries. Mithridates, King of Pontus, could take a large dose of arsenic with impunity, and the mountaineers of Savoy and southern Switzerland use arsenic habitually as a safeguard against pulmonic affections. The poor Norsemen often mix their daily bread with a whitish mineral powder, more from necessity than a vitiated taste, we hope; but a similar substance is employed by the natives of Brazil and other parts of tropical America without any such excuse. The name of Panama is derived from *panamante* (originally *pan-de-monte*, mountain-bread), a substance which the Indians of Central America prepared from a mealy gypsum-powder, found here and there in the Sierra. Humboldt describes a tribe of Indians in northern Brazil who have been addicted to the use of panamante for generations, and were distinguished by a monstrous protuberance and induration of the upper abdomen. When the French were masters of St. Domingo their negro slaves had contracted a similar passion, and could only be restrained by barbarous punishments from indulging it to excess.

It would be erroneous to suppose that cannibalism has become quite extinct. Among the Dyaks of Borneo there is a recurrence of the outrage after every petty feud and raid, and many of the South Sea Islands are still infested with secret anthropophagi. The Pintos, an aboriginal tribe of Yucatan, have repeatedly been detected in cannibal practices; and phenomenal cases have occurred in Asia after every protracted famine. In 1873 the Chasseurs d'Afrique captured an old Kabyle on the plateau of Sidi-Belbez (Algiers), who had committed innumerable murders to indulge this horrible passion, and had twice been caught *in flagrante* by his countrymen, who contented themselves with giving him a good hiding the first time, and released him on another occasion when they found his victim had only been a French settler!

The slaughter-houses of every large city are visited by delicate ladies,

who hope to cure affections of the respiratory organs by a draught of fresh blood, but who would inspire a Hindoo with a cannibal terror more intense than that produced in the Algerian settlements by the above Kabyle. Herodotus relates that the Scythians executed their criminals by a potion of fresh ox-blood, and recommends this as a more humane method than capital punishment by the sword, though inferior to the hemlock-cup. "For opening the gates of Tartarus," says Haller, "there is nothing like a good narcotic. If I should have occasion to leave this world, I would no more think of shooting myself than of leaving town by being fired from a mortar, when I could take the stage-coach."

The Turks shudder at seeing a Frank swallow oysters, and even in the cities of Europe and North America we find individuals with similar antipathies; and I know an old professor who passed half a century in St. Petersburg, and suffered grievously from an unconquerable aversion to caviare. Caviare is the salted or pickled roe of the sturgeon—not quite so bad as Schnepfendreck, a North German delicacy, which consists chiefly of the fæces of the common woodcock.

Professor H. Letheby, food-analyst for the city of London, is responsible for the following account of a mandarin's dinner, given to an English party and some distinguished natives of Hong-Kong:

> The dinner began with hot wine, made from rice, and sweet biscuits of buckwheat. Then followed the first course of custards, preserved rice, fruits, salted earthworms, smoked fish and ham, Japan leather (?) and pigeons' eggs, having the shells softened by vinegar; all of which was cold. After this came sharks' fins, birds' nests, deer-sinews, and other dishes of an appetizing and dainty character. They were succeeded by more solid foods, as rice and curry, chopped bear's paws, mutton and beef cut into small cubes and floating in gravy; pork in various forms, the flesh of puppies and cats boiled in buffalo's milk; shantung or white cabbage and sweet potatoes; fowls split open, flattened and grilled, their livers floating in hot oil, and cooked eggs of various descriptions, containing embryo birds. But the surprise of the entertainment was yet to come. On the removal of some of the flower-vases a large covered dish was placed in the center of the table, and at a signal the cover was removed. The hospitable board immediately swarmed with juvenile crabs, who made their exodus from the vessel with surprising agility, for the crablets had been thrown into vinegar before the guests sat down, and this made them sprightly in their movements; but, fast as they ran, they were quickly seized by the nearest guests, who thrust them into their mouths and crushed them without ceremony, swallowing the strange gelatinous morsel with evident gusto. After this *soy* was handed round, which is a liquor made from a Japan bean, and is intended to revive the jaded palate. Various kinds of shell and fresh fish followed, succeeded by several thin broths. The banquet was concluded by the costly bird's-nest soup, the dessert being a variety of scorched seeds and nuts, with sundry hot wines and tea.

But the mandarin was astonished in his turn by finding ice-cream among the delicacies of an English refreshment-table, and predicted disastrous consequences from its habitual use. Ice, without doubt, is in-

jurious, but not more unnatural than our custom of swallowing boiling-hot soups and stews.

In the use of hot spices the Spaniards and their South American kinsmen exceed every other nation. *Chilé colorado*, or red pepper, is one of the mildest condiments of a Peruvian kitchen. The *yerba blanca*, a whitish-green herb which is used raw with olive-oil on sandwiches, and enters into the composition of various ragouts, is described as resembling the *lapis infernalis* in its effect on a normal tongue. A Mexican can chew up a handful of red pepper as we would so much dried fruit, and eats onions, garlic, and salted radishes as a relief from more pungent tastes. I must believe it, on the testimony of the entire medical faculty of the city of Bremen, that a man who was treated in their city hospital for a most mysterious complaint settled the dispute of his physicians by confessing a weakness for *tan-water*—the fiery infusion of tan-bark, in which he had indulged rather to excess in the last year. The inhabitants of southern Russia, especially of the Dnieper Delta, are all day long chewing the aromatic seeds of the sunflower and different kinds of pumpkin-seeds, which appears to be less a stimulation than an idle habit, like the use of chewing gum in our boarding-schools.

Timour the Tartar celebrated his victories by solemn barbecues of broiled horseflesh and fermented mare's milk, or koumiss, which is still a favorite drink of his countrymen. Tartars also use a decoction of the poisonous fly-sponge as a stimulating beverage, and according to Vambéry have a national foible for morsels of superannuated meat, of an aroma which the French term of *haut-goût* would hardly begin to describe. Yet these same Tartars might shudder at being confronted with a dish of that Limburg delicacy which finds its way into the best hotels of Continental Europe. I can not forget the emphatic protest of a Spanish officer who was invited to partake by a German admirer of the questionable dainty, in the cabin of a Havana steamer. "You think it unhealthy to eat that?" inquired the Hamburger, in polite astonishment. "Unhealthy?" exclaimed the Hidalgo, with a withering look and a gasp for a more adequate word—"no, sir! I think it an unnatural crime!"

THE MONSTROUS IN ART.

By SAMUEL KNEELAND, A. M., M. D.

MANY persons of culture and poetic imagination, with a keen sense of the beautiful, but with little knowledge of living nature, believe and maintain, and in one sense justly, that certain works of old and modern masters are works of high art, from color, grouping, elegance of figures, and the various accessories which, in themselves, or by ideas and emotions excited by them, make painting and sculpture very powerful agents in instructing and elevating man-

kind. According to a recent definition of art, that of Mr. Benjamin, "Art may be said, in a general way, to spring from the poetic yearnings and emotions suggested by aspirations after the true, the good, and the beautiful . . . . the material means for expressing such feelings appealing to the imagination through the eye by the use of external forms." The highest art, according to this definition, must include the good, the true, *and* the beautiful; the physically beautiful, or the beautiful and the good, is not the aim of the highest art; the true must be added for a work that shall rank *as* such for all time.

A painting or a statue may be beautiful, as interpreting the emotions or religious beliefs of man at any particular epoch of his history; but, if the ideas symbolized or suggested become untrue or unbeliefs, they thereby lose in artistic value, and no longer belong to the domain of the *highest* art. Nothing that is simply temporary, no mere conventionalism, however beautiful at the time, which becomes unnatural or impossible as man advances in knowledge, can, in my opinion, belong to the *highest* art.

Any one who discusses the principles of art from the point of view of the true, without reference to the beautiful, labors under great disadvantages, arising chiefly from the intimate connection between art and religion. Most of the best works of the old and modern masters, in painting especially, embody the theologic beliefs of the period, and suggest ideas of spiritual, not of physical truth. As there is evolution in nature and in theology, let us hope there is also evolution in art; we can not stand still in any matters of knowledge, for, if we go not forward, we practically go backward, as all the interests of humanity will leave us behind.

The faith in spiritual truths which artists embody by symbols, without being of necessity weakened, will be modified by knowledge, and thus render forms once suggestive of beauty and goodness now untrue and monstrous. I know that the old objection will be urged that, though *scientific* truths rest upon *reason*, there are *spiritual* truths incapable of demonstration, emotions above and beyond reason. Even educated persons have very indefinite and very different ideas on the nature of the mental evidence arising from religious aspirations, and the wish is very apt to be "father to the thought" in symbolic representations of supernatural attributes and powers.

There may be no contradiction in the belief in the existence of spiritual beings far above us in power, and that such may even communicate with mankind in various ways; but, if they assume to the eye the shape and functions of humanity, they should be made to conform to the laws of human anatomy and physiology.

Those who are easily and strongly moved by these *spiritual* emotions will not listen to *reason*, which they maintain has nothing to do in the premises. Let such cling to their spiritual truths, and to the artistic representations which embody and suggest them, and regard

them as high art if they please ; but, at the same time, let the truth as it is in nature and reason have a chance to appear in the field of art. If Theology and Art are sisters (and they are in one sense), let them be *twin* sisters, walking hand in hand, with the stamp of truth, as we know it, in every line, word, and feature, irrespective of any pious frauds or false rules of art bequeathed to us by past ages. Spiritual truth ought to be reënforced by scientific truth, and art as well as religion will be the gainer.

I know very well that I am treading here on debatable ground, and that those who follow, or think they follow, the *ideal* in art, will rise as a host against me. My object here is to show that art has too much neglected the laws of living animal nature ; that mythology has been followed rather than zoölogy, where attention to the latter would have been just as good for all the purposes of art, and far better for the interest of truth. In one sense, the *ideal* is the ultimate aim of art, if by that is meant that it shall suggest true ideas, and excite emotions which shall educate and elevate ; but not, if by the ideal we signify the merely imaginary, fanciful, unnatural, and impossible, however beautiful such creations may be.

Even admitting that a work of high art by the *old* masters may include the impossible, the unnatural, as symbolic, if judged by the knowledge of the times and the motives of the artist, that is no reason for advocating similar errors in the nineteenth century. It seems to me that the symbolic in art bears a relation to the natural and the true, similar to that which the hieroglyphics of the ancient Egyptians do to the written languages of the moderns—the one indefinite, suggestive, but variously interpreted, local, and temporary ; the other definite, positive, universal, and for all time unmistakable—and that we might as well go back centuries and adopt the hieroglyphic as the simply symbolic without reference to its truth in art. Symbolism is the visible expression of a myth, possessing a variable amount of truth and a large amount of error ; both are characteristic, in the progress of civilization, of the lower phases of development.

I speak of art from the *natural*, not the *imaginative* point of view, and my arguments are addressed chiefly to such as have a fair knowledge of anatomy, physiology, zoölogy (living and fossil), and the laws of development in the animal kingdom. As, however, many deeply interested in the progress of art have very little acquaintance with living nature, it will be necessary for me to enter into some details, tiresome perhaps for the scientific expert, but important for the popular understanding of my argument.

While I do not deny the artistic value of the imaginative, symbolic, and ideal, I maintain that such, at the present time, if contrary to nature, is not the *highest* art, is not necessary for the expression of the most ennobling ideas, and is not demanded by the most exalted aspirations of humanity.

The Greeks and Romans, whose principles of art the moderns have chiefly imitated, personified certain ideas of their social state, deified and worshiped them. As a general rule, they found in nature the types which they idealized; in some cases, from ignorance, superstition, or love of the marvelous, they departed from nature, and to that extent, in my judgment, their art was false. Art, as I understand it, should be the interpreter of nature, without too servile an imitation; art may transfigure nature, but should never be false to it; *un*natural and, I may add (as far as knowledge is concerned), *super*natural art is *monstrosity.*

By *monstrosity* (which is here used in its scientific, not its popular sense) I mean nothing ugly, misshapen, gigantic, or dwarfish, or with any congenital anomalies of conformation, rendering impossible the accomplishment of the ordinary functions of life, but the union of parts incompatible with each other, and impossible when brought to the test of reason and natural laws, however beautiful or suggestive they may be, and however consecrated by unquestioning ages of social, religious, and æsthetic acceptance. It is true, as Goethe has well said, that "it is in her monstrosities that Nature reveals to us her secrets," which we now know are but the expressions of natural laws; I hope to show that in the monsters of art she only reveals to us her weakness.

To illustrate my meaning by a few examples: The ancients, when they represented Saturn as Chronos or Time, the father of the gods, as an old man devouring his children (hours and days and years), armed with a scythe by which he cut down the generations of man, conceived a beautiful, expressive, and natural idea; but when they put upon him a pair of wings, to indicate the velocity of his flight, he became a monster, for the reason that arms *and* wings *and* legs are incompatible, and can not exist in nature, as we know the vertebrate skeleton. Six pairs of *limbs* are conceivable with the vertebrate skeleton, but wings without bones to support or muscles to move them are not conceivable.

Among other winged and impossible monsters created by ancient art, expressing long-cherished ideas, is Cupid or Love — though it would be an anatomical impossibility to move said wings; he must drop either his arms, with the bow and arrows, or his wings. So Mors or Death, represented by a skeleton, has enormous wings, with not a muscle to move either bone or pinion; Morpheus the minister of Somnus or Sleep, Psyche the Soul, and Zephyr the West Wind, have the wings of a butterfly—a mixture of vertebrate and invertebrate characters entirely incompatible.

The wonderful adaptation of the human skeleton to its uses—the contour of the spine, which renders erect position and biped locomotion possible in him alone of mammals; the lower limbs for locomotion only; the upper limbs for prehension, and the service of the senses resident in the head—all these imply a certain bony structure and corresponding muscular developments. If you add another pair of limbs as wings,

you make an anatomical nondescript, an impossible monster, devoid of truth, false to nature, odious to the highest art.

The smooth, comparatively hairless skin of man, angel, or devil, is incompatible with the feathers of a bird's wings; his bony tissue has not the air-spaces, nor does it communicate with the lungs, as in the bird, which is thus rendered specifically lighter. His thorax or chest is too movable for the support of muscles of flight, even if angels were made armless and winged; his breastbone is smooth, not keeled as in birds; so that flying angels must of necessity be deformed and pigeon-breasted if they had muscles of flight. The biped attitude of the bird requires a change of posture, an horizontality, to get the center of gravity between the shoulders for flight, which would render man a ridiculous figure. As far as we know locomotion in the animal kingdom, the wings and the legs are not moved at the same time in progression in the air; it is seen only in some birds with very rudimentary or short wings, who use their wings to help them in running on the ground, which is not the ideal of the artist's angel. The ideal, or that which suggests the idea of a heavenly messenger, need not be false to nature; an angel *without* wings is just as ideal and suggestive, and not an anatomical impossibility. That the form of an angel need not of necessity have wings is shown by a painting in the museum at Naples of the "Holy Family," attributed to an artist of the Florentine school, in every respect admirable, and usually called the "Virgin of Purity." The angels have no wings, and carry lilies in their hands; wings would have added nothing to the picture, which is remarkable for its natural beauty.

It seems to me that an angel *without* wings, floating upon surrounding clouds (like the "hours" in Guido's "Aurora"), is a much higher symbol of a supernatural messenger than the conventional winged one; it indicates a spirit, an ethereal substance, a mere outline figure suggestive of motion; but if you add the unnatural and impossible wings to the arms, you make a monster in human form, defy the process of reasoning, rob the image of its spirituality, and degrade it to a coarse and earthy symbol, inconsistent with the idea it is intended to convey.

I will allude to a few other monstrosities in ancient art, copied by the moderns, to further illustrate my meaning.

It was natural that a barbarous people, at the first and distant view of men on horseback, should imagine that they were creatures half man and half horse; hence the fabled Centaurs, a people of Thessaly, who were among the earliest to bring the horse into the service of man. As is well known, the Centaurs had the head, arms, chest, and body of a man as far as the hips, joined to the chest, body, and four limbs of the horse. Though a Centaur *at rest* is a noble figure, symbolic of strength, swiftness, intelligence, and protection of man by the Olympian gods, the position which the creature was supposed to assume in his contact with man, as shown in many mural tablets found at Pompeii, and now in the museum at Naples, is ridiculous and impossible.

Just imagine, if you can, the condition and position of the organs in this case. Let it be all right to the point where the horse joins the man; the excretions of the man, with his mass of intestines and other organs of digestion and secretion, must pass through the chest of the horse, filled with this creature's lungs and heart and great blood-vessels, involving another set of digestive and excretory organs, another form of skeleton, with the muscles, limbs, and skin of the horse. The man must eat for the horse, as his is the only mouth, which would necessitate a diet repugnant even to the most fanatic vegetarian. We naturally inquire if he must also breathe for the horse; there must be double lungs, double heart, double stomach, double intestines, double body, six limbs, long tail, hoofs and hands—a monster considerably worse than the single-bodied but six-limbed art-angels above alluded to. If we accept Hercules and Achilles, we can not accept the Centaur Chiron, their instructor.

Among other monsters created by the ancients and adopted by the moderns is Pan, the chief of the rural deities, with his attendant Fauns and Satyrs, having the head, arms, and body of a man, and the hairy lower limbs and hoofs of a goat. How they managed to walk erect on such feet, and preserve their center of gravity where it ought to be, to say nothing of the incompatibility of the human pelvis and the hircine legs in bones and muscles, is a puzzle for the physiologist. The fact that the theologic devil is usually represented very much like the god Pan, with all his inconsistencies and impossibilities, shows at once the origin and the absurdity of the idea; to his extreme ugliness, exciting a *panic* fear, is doubtless due the selection of his figure to represent the theologic spirit of evil, upon whose existence and domain many a *spiritual panic* has rested.

Neptune, the god of the seas, was represented in an immense shell drawn by impossible sea-horses, and surrounded by equally impossible Tritons, half man and half dolphin, and Nereids, half woman and half fish.

There is a large class of ancient artistic conceptions, freely copied by the moderns, not anatomically monstrous, but physically and physiologically impossible—such as Atlas supporting the globe on his shoulders; caryatides, female figures used by architects to support roofs and heavy weights; and other similar conceptions, painful to look at if we apply the tests of reason and common sense. I would say here that, in mere ornamentation, conventional representations suggestive of the intended image may be legitimately and artistically used with good effect; but if they are contrary to nature, whether on a candlestick or a church tower, they must belong to the *lower* spheres of art; and no metaphysical subtilty, no assumption of æsthetic culture, no aspirations after an imaginary and impossible ideal, ought, in this nineteenth century, to raise them to the highest position in art.

As the so-called ideals of the ancients must have had some things in

nature to suggest them, it may be well to examine, in the light of the present day, for *their* justification, but not for *ours* (who have copied them and ought to have known better), what they really had as foundation for these monstrous forms in truth, real or apparent.

The conception of the Centaurs, we have already seen, is easily explained by the appearance of a man on horseback. Workers in metals, exposed to the intense heat and glare of their fires, would naturally protect their faces by masks of wood or leather, as makers of plate-glass, for example, do now, looking out through a single median hole—hence the fabulous Cyclops. The Satyrs were evidently derived from some of the large anthropoid apes, which must have been known to primeval man.

The above-mentioned monsters, and many others which admit of a natural explanation, did not originate with the Greeks; they obtained them from the Egyptians, and these from antecedent races long before the historic period. The existence of man with the mammoth, mastodon, Irish elk, cave bear and lion, among quadrupeds—with the dodo, dinornis, and epiornis, among birds—suggests that perhaps he may have lived with the pterodactyl and serpent-like marine lizards, or their modified descendants, in the Tertiary or a more remote epoch. The mastodon, or the mammoth (either), might easily have been made into the Minotaur killed by Theseus; the Nemean lion slain by Hercules may well have been the *Felis spelæa* of the bone-caves; the rhinoceros would make an excellent foundation for the unicorn; the cuttle-fishes of the Mediterranean, with their eight or ten arms, moving independently, and armed with terrible suckers, would readily suggest the many-headed hydra, also killed by Hercules.

The Sirens, and other marine creatures of human likeness, are the natural outgrowths of the imagination of sailors returning from long voyages, without the sight of a woman for months or years. Seeing manatees and seals reclining on the shores, holding their young in their arms while suckling them, like all mammals, the semi-human faces, the womanly position, and the tender care and anxiety for their young in this act—their hearts would be filled with such joy at thoughts of home, and their eyes with tears long pent up, that the combination of indistinct vision and excited imagination would transform the creatures they saw into the beautiful women they longed to see.

At Stabiæ have been found mural tablets representing Nereids, or horses with the tail of a fish, evidently suggested by the little sea-horse (*hippocampus*) of the Mediterranean; in some the head of the horse is replaced by the head of a tiger—not a very abrupt transition.

The fauna of the Tertiary age from the Miocene down, which there is some reason to believe passed before the eyes of primeval man, would afford ample material for gorgons, dragons, sylphs, and satyrs, leviathan and behemoth, and the whole list of ancient and modern fabulous monsters. The birds with teeth, and the winged lizard of the Secondary

age (the pterodactyl), known very well by its fossil remains, if clothed with flesh and provided with limbs and wings, would make a creature in some respects like the dragon of fairy tales.

The mythical gigantic kraken of the northern seas has a legitimate descendant, and is simply an exaggerated type of the giant *architeuthis* of the coast of Newfoundland, of which a specimen has recently been exhibited in this city.

The "roc' of Sindbad the Sailor was not much larger than the epiornis of Madagascar and the dinornis of New Zealand, more than twice the size of the ostrich. The Eastern imagination, on the basis of these great birds actually coexisting with man, would naturally put on the wings which birds of this type did not possess, and then the transportation of a man into the "Valley of Diamonds" would be quite possible.

These forms could hardly have been imagined by barbarous man; they must have had their prototypes in nature: they are, therefore, not *ideal* forms, but, in a zoölogical sense, *real* forms.

An artist may be ignorant of history, chronology, and zoölogy, as well as of anatomy and physiology, and may be a perfect child in his knowledge of common things beyond his immediate every-day sight. Even Raphael, Albert Dürer, Salvator Rosa, Vandyke, Paul Veronese, Poussin, and many others, have greatly erred in these respects. Instances might easily be mentioned, but I will merely allude to them to show that art has not always been true to nature and fact, and to say that we are not only at liberty, but in duty bound, to protest against all untruthfulness, whether it offend the eye or the reason.

Let me not be understood as pretending to say that there is *no art* or beauty in purely fanciful creations in painting or sculpture. There is a place, and a genuine one, for the allegorical, the symbolic, the mysterious, the unreal, if you will, in art; but such art, from the very fact of its unreality, untruthfulness, and impossibility, is, I maintain, a *lower* type than that which is strictly natural and true. Wings of angels, as messengers of glad tidings or guardian spirits, are, as fanciful creations, beautiful, though untrue; winged heads, as suggesting the swiftness of thought and intelligence, are acceptable as symbolic, though impossible: but all such creations should take a subordinate position in art, and in proportion as the symbolism departs from the true, the known, and the conceivable. We must not confound the results of the imagination, which exaggerates possible parts seen, or supposed to be seen, in nature, with the wholly unreal products of the fancy; we may admit their beauty, but, however definite and pleasing their outlines, if their combinations, when tested by reason, are impossible, they must be regarded as lower than the natural. They may answer for gas-fixtures, monuments, memorial windows, and various articles of household decoration, but not for anything demanding admiration and following as a work of *high* art.

Let me now bring to your remembrance a few celebrated works of

acknowledged art, to show my meaning more clearly, and to give direction to the criticisms which I wish to make.

The Sistine Madonna of Raphael is without doubt the best and most admired representation of "motherhood" in the whole range of art. I think the experience of most persons who have seen it, even in engravings or photographs, will justify the assertion that they are so carried away by the beauty and grace of the mother and child, that they do not at first see the host of surrounding angelic heads, nor the two "cherubs" at the bottom of the picture. I allude here only to the latter, which, in my opinion, detract from the grand effect, and introduce a disturbing and inferior element which had better been left out. The expression of their faces is innocent, angelic, if you please; the attitudes are graceful, natural, and childlike; nevertheless, they are unnecessary, impossible creatures, and are, if anything, six-limbed or hexapod vertebrates, when, as naturally formed children, they would have been just as symbolic, though quite as insignificant and useless. Though their parts, separately, exist in nature, as a combination they are impossible, and therefore, except as misplaced symbols, not artistic.

In this connection I would remark that, in my opinion, man has never imagined, and can never imagine, any symbolic form in art or poetry not suggested by his surroundings; there are ugly things enough and beautiful things enough in nature to suggest any forms represented by art; but a compound of man and bird or beast or insect could never be suggested as a *whole*, without a previous knowledge of the *parts*.

It is not a very great step from the Aphrodite and Eros of the early Greeks (not the sensual Venus and Cupid of the later Greeks and the Romans), by which they represented all that was tender and lovable in woman, to the Virgin and Child. The step is still less from Cybele or Rhea, the wife of Saturn and the mother of Jupiter or Jove, whose name was in Greek *Theotokos*, in Latin *Deipara*, meaning the "mother of God"; Jove, the king of the gods, suggests in name as well as attributes the Hebrew Jehovah. The Madonna, it seems to me, is simply an evolution from pagan mythology to Christian art.

In some old religious paintings angels are represented as winged heads, without body or limbs. Now, these artists painted better than they knew; for, according to the acknowledged principles of philosophical and comparative anatomy, the anterior limbs, whether arms, wings, legs, or fins, are appendages to the occipital or posterior vertebra of the skull; in the fish, in fact, the pectoral fins, the anterior limbs, are attached by bony connection to the back part of the skull. But, though winged heads are anatomically legitimate, physiologically we can not understand the action or the origin of any muscles sufficiently powerful to move the head, to say nothing of the other incongruities, especially of the union of human hair, face, and skin with the feathers of a bird. As pure symbols these are acceptable for the infancy of the human race, but are not therefore to be perpetuated by the moderns. Mother Goose

is well enough for the child, but distasteful and absurd for the man, even though under its symbolic language much truth be hidden.

In modern art, the "Night" and "Day" by Thorwaldsen, so well known and so much admired, are similar specimens of the "Monstrous in Art"; the symbolic beauty of the work is such that we do not notice the untruth and the impossibility of the wings. The "Theseus slaying the Centaur," by Canova, displays another form of six-limbed monster, whose impossibility is evident after what has been said above, without the excuse of symbolism. In all our large cities we find symbolic paintings of an "angel overcoming Lucifer," in which are seen the same feathery pinions, widely spread and in violent action, with no possible means for their support or movement.

Here, as in many paintings and statues which will readily be brought to mind, as in the wall decorations at Pompeii, the "Victories," etc., we see a pretense of motion more or less active, and a possible use for wings could they exist. But what shall be said of the large and conspicuous tablets at the corners of the "Museum of Fine Arts" in Boston, in one of which the central and principal figure, styled the "Genius of Art," and so indicated by letters, is one of these impossible winged monsters?

The idea, however, is not original, but is an imitation of ancient art, in which a genius or tutelar god of man or his industries is usually represented with wings as well as arms.

In the above-mentioned tablet we see a nude figure, seated comfortably upon a chair, presumably quiet, with outstretched arms welcoming the nations who are bringing their representative works as offerings at the shrine of art; and yet this "Genius of Art," not content with arms and legs, *at rest*, has immense outstretched wings, indicative, if of anything, of active *motion*—anatomically, an impossible six-limbed creature; physiologically, an absurdity; implying the contradictory states of rest and motion at the same time; and, therefore, artistically, an unnatural, nondescript monster. A similar tablet is upon the other corner, if possible, more ridiculous than the first; the genius of art has found a winged brother monster, called "Industry." The two, each with wings and arms, are quietly seated, with wings widely stretched—we see in this the same anatomical impossibility, the same physiological absurdity, the same degradation of symbolism. As man is never intentionally absurd, let us attribute these and similar monstrosities to ignorance of nature's laws. If this be art, there is no gulf of absurdity too wide for symbolism to clear at a single bound.

Other winged angelic hexapods may be seen at each corner of the tower of the church on Commonwealth Avenue, with trumpets at their mouths; it is difficult to see how the wings in this case add anything but the ludicrous.

No permanence of embryonic conditions—no excess of growth, no union of parts of more than one individual—can explain or justify these

and similar monsters ; and surely no rules of art can demand the continued perpetration of such absurdities, in painting or sculpture, even as symbols.

In my opinion, then, there can be no high art, as there is no truth and no real significance, in external forms unknown to anatomy and physiology ; truth in art must not be divorced from truth in science, nor the truly beautiful from nature. The exterior should translate, as it were, the interior ; and, whether we study the human or the animal figure, from the point of view of surgery, art, or philosophical anatomy, the natural type, the laws of structure and growth, the correlation and the organic harmony of parts, should in every case lie at the foundation. The idealism of *ancient* art is, I believe, a pretense of the moderns ; their *ideal* is the *real*, *magnified* by the *imagination*. The *modern* ideal of much that is considered high art is too often the impossible, the absurd, the monstrous, the incomprehensible.

The conscientious and real artist, though he may be ignorant of, despises not anatomy ; it is only the superficial and the conceited who fancy that it is a laudable and independent spirit which allows imagination, under the pretense of symbolism, unguided by knowledge, to dictate the rules of art. Albert Dürer, Leonardo da Vinci, Jean Cousin, were well versed in anatomy ; it would have been better had the genius and imagination of Raphael and other great artists been tempered by an accurate knowledge of the real.

Herbert Spencer says, "Only when genius is married to science can the highest results be achieved"; to which Mr. Benjamin adds, in his essay already quoted, "But such science should be the intense study of nature even more than of art."

In our day, when reason is supreme, the thinking world can not be made to believe that *progress* means *evil*, even though it modify ideas of things once considered sacred and beyond reason; and any belief, practice, sentiment, or influence, which can not bear the light of reason, and hence can not be said to be founded on truth, deserves to be removed as a bar to human progress.

It has been said, and no doubt truly, that as *knowledge in*creases, the *imagination de*creases ; in such an event our ideal will soon become the real, without exaggeration, and nature and art will no longer be divorced, even in appearance. Increasing intelligence is the great and never-ceasing iconoclast which breaks to pieces the images created by imperfect knowledge of facts.

This is about the sum of the arguments in favor of symbols, once suggestive of the good and the sacred, but since proved to be fallacious and founded on error, namely, that those who originated and used them for purposes of good believed them to be true and beautiful, and therefore that for all time, or at the present time, they are worthy of imitation and belong in the realm of high art.

Must we, then, give up our saints, angels, and devils, and other

venerable, beautiful, and ugly monsters in art, so endeared by childish memories and fears? United to and supported by ignorance and blind belief, they stood as truths in the infancy of the race; separated from these, and subjected to the light of reason and knowledge, they fall from our acceptance as beliefs, and from the highest sphere of art, where nature and truth should henceforth be the grand aims of the artist.

Should any object that following strictly the laws of nature will have a tendency to lower the aspirations of the artist, we may refer to a sister science in defense of our position. The signs of the times have convinced many a timid but reasoning soul that fidelity to truth and nature can never injure religion, however much it may shatter ideal theologies; nor in art can it injure anything but the false and the temporary—the grand underlying principles resting on the basis of eternal truth. Are we not justified, then, in saying, "The essentially beautiful must be in nature; it can not be beyond it, above it, nor below it; the *merely ideal in form* can have no real existence in the mind of man"?

NEW GUINEA AND ITS INHABITANTS.

By ALFRED RUSSEL WALLACE.

I.

IMMEDIATELY north of Australia, and separated from it at Torres Straits by less than a hundred miles of sea, is the largest island on the globe—New Guinea, a country of surpassing interest, whether as regards its natural productions or its human inhabitants, but which remains to this day less known than any accessible portion of the earth's surface. Within the last few years considerable attention has been attracted toward it by surveys which have completed our knowledge of its outline and dimensions, by the settlement of English missionaries on its southern coasts, by the explorations of several European naturalists, and by the visits of Australian miners attracted by the alleged discovery of gold in the sands of its rivers. From these various sources there has resulted a somewhat sudden increase in our still scanty knowledge of this hitherto unknown land; and we therefore propose to give a general sketch of the island and of the peculiar forms of life that inhabit it, and to discuss briefly some of the interesting problems connected with its indigenous races.

It has hitherto been the custom of geographers to give the palm to Borneo as the largest island in the world, but this is decidedly an error. A careful estimate, founded on the most recent maps, shows that New Guinea is considerably the larger, and must for the future be accorded the first place. In shape this island differs greatly from Borneo, being

irregular and much extended in a north-northwest and south-southeast direction, so that its greatest length is little short of 1,500 miles, a distance as great as the whole width of Australia from Adelaide to Port Darwin, or of Europe from London to Constantinople. Its greatest width is 410 miles; and, omitting the great peninsulas which form its two extremities, the central mass is about 700 miles long, with an average width of 320 miles, a country about the size of the Austrian Empire, and, with the exception of the course of one large river, an absolute blank upon our maps.

This almost total ignorance is the more remarkable when we consider how long the country has been known, and how frequently its shores have been visited. It was discovered in 1511, even earlier than Australia, and from that time Spanish, Portuguese, Dutch, French, and English vessels have continually passed along its coasts. Most of our early navigators—Forrest, Dampier, and Cook—visited New Guinea, and have given us some account of its inhabitants; while, more recently, many exploring and surveying ships—the Coquille and Astrolabe, under French; the Rattlesnake, Fly, and Basilisk, under English; the Triton and Etna, under Dutch commanders—have added to our store of information. Among private naturalists and explorers, the present writer was the first to reside some months in New Guinea in 1858; since which time Dr. Miklucho Maclay, a Russian; Dr. Beccari and Signor d'Albertis, Italians; Dr. A. B. Meyer, a German; Mr. Octavius C. Stone, and several English missionaries—have all made important explorations and added much to our knowledge of the natural productions of the island and of the tribes residing on or near its coasts.

From these various sources we have obtained a tolerable knowledge of the outside margin of the country, but never extending more than twenty miles inland, except in the case of the Fly River, which Signor d'Albertis ascended for nearly 500 miles, reaching a point somewhat beyond the center of the island. The northwestern and southwestern peninsulas of New Guinea are the best-known portions, and both seem to be mountainous throughout. In the north, Mount Arfak, a little beyond Dorey Harbor, is from 8,000 to 10,000 feet high, while in the southeast the Owen Stanley Range has several peaks which reach elevations of from 10,000 to 13,000 feet. The Charles Louis Mountains, commencing near the south coast, east of Triton Bay, appear to run far in a southeasterly direction, and their summits are believed to be snow-clad, and are probably at least 18,000 feet high. If they continue eastward in the same general direction they would pass about 100 miles to the north of D'Albertis's farthest point on the Fly River, and perhaps form a great curve till they merge in the Owen Stanley Range in the southeast. This, however, is mere conjecture, for throughout the whole course of the Fly River the land was low, and only on one occasion were high mountains seen to the northwest. Combining this with the

fact that for a length of nearly 700 miles the south coast of New Guinea is low and swampy, with no high land anywhere visible, we are led to conclude that there is probably a continuous range of lofty mountains toward the north, while the south consists of wide alluvial tracts and of slightly elevated inland plains. This part of the island would thus somewhat resemble Sumatra turned round, but with higher mountains, which are probably not volcanic, and with a considerably greater width of land.

Although the Fly River penetrates so far into the interior, its size and depth in its upper portion are by no means what we should expect in a stream fed by a lofty mountain range close to the equator. It is therefore almost certain that larger rivers exist farther west; while another large river certainly flows northward, having its mouth in a delta at the eastern extremity of Geelvink Bay. Until these rivers are explored, and at least the lower slopes of the hills ascended, we can not be said to have much real knowledge of the interior of New Guinea.

Situated close to the equator, and extending only eleven degrees south of it, the climate of New Guinea is hot and uniform, and the rains abundant ; leading here, as elsewhere in similar situations, to the growth of a luxuriant forest vegetation, which clothes hill and valley with an ever-verdant mantle. Only on the coasts nearest to Australia, and probably influenced by the dry winds from that continent, are there any open or thinly wooded spaces, and here alone do we find some approach to the Australian type of vegetation in the occurrence of numerous eucalypti and acacias. Everywhere else, however, even in the extreme southeast peninsula and adjacent islands, the vegetation is essentially Malayan ; but Dr. Beccari, who collected plants extensively in the northwestern peninsula and its islands, was disappointed, both as regards its variety and novelty. On the Arfak Mountains, however, he found a very interesting subalpine or temperate flora, consisting of araucarias, rhododendrons, vacciniums, umbelliferæ, and the antarctic genus *Drimys*. The forests of New Guinea are everywhere grand and luxuriant, rivaling those of Borneo and Brazil in the beauty of their forms of vegetable life ; and we can not consider the collections yet made as affording more than very imperfect samples of the treasures they contain.

The animal life of this great island is better known, and is perhaps more interesting. Its terrestrial mammalia are, however, singularly few, and, with the exception of a peculiar kind of wild pig, all belong to the marsupial tribe or the still lower monotremes of Australia. The tigers, apes, and buffaloes, described in the fictitious travels of Captain Lawson, are here as much out of their real place as they would be in the Highlands of Scotland; while the tracks of large animals, supposed to be rhinoceros or wild cattle, actually discovered by recent travelers, are now ascertained to be those of the cassowary, which, so far as we yet know, is the largest land-animal of New Guinea. Large birds

were also seen and heard, whose spread of wing was estimated at sixteen or twenty feet, and which beat the air with a sound compared to the puff of a locomotive ; but these are found to be only a well-known hornbill of very moderate dimensions. In place of these myths, however, we have some very interesting realities, the most remarkable, perhaps, being the tree-climbing kangaroos of rather large size, which, although but slightly different in external form from the jumping ground-kangaroos of Australia, hop about among the larger branches of trees, on the leaves of which they feed. They have a bushy tail, with somewhat shorter hind legs and more curved claws than their allies; and they afford a curious example of the adaptation of an animal to new conditions of life very different from those for which its general form and structure seem to fit it. Such a modification may, perhaps, be traced to a somewhat recent separation of Australia and New Guinea, when the kangaroos which remained in the latter country, not finding a sufficiency of herbage for their support in the dense forests, began to feed upon leaves, and ultimately became adapted, with as little change as possible, to a truly arboreal life. The entire absence of beasts of prey would favor this adaptation, as the coincident acquisition of swiftness of motion or powers of concealment is thus rendered unnecessary ; and the tree-kangaroo accordingly remains a slow-moving creature, just able to get its own living, but in all probability quite unable to cope either with enemies or competitors.

The birds, like the mammalia, are mostly of Australian types, but nevertheless present many peculiarities. Most celebrated of all are the birds of paradise, forming a distinct family, containing more than twenty-five different species, all confined to this island and the immediately surrounding lands. These singular birds are really allied to our crows and magpies, but are remarkable for their special and varied developments of plumage. In most cases tufts of feathers spring from the sides of the body or breast, forming fans, or shields, or trains of extreme beauty. Others have glossy mantles or arched plumes over the back, strange crests on the head, or long and wire-like tail-feathers. These varied appendages exhibit corresponding varieties of color. The long trains of waving plumes are golden yellow or rich crimson, the breast-shields, mantles, and crests are often of the most intense metallic blue or green, while the general body plumage is either a rich chocolate brown or deep velvety black. All these birds are exceedingly active and vivacious, the males meeting together in rivalry to display their gorgeous plumage, while in every case the female birds are unornamented, and are usually plain or positively dingy in their coloring. From an unknown antiquity the natives of New Guinea have been accustomed to preserve the skins of these beautiful birds, and barter them with the Malay traders, by whom they are universally known as "burong mati," or dead birds, because they had never seen them alive. As the natives used always to cut off the feet in order to preserve them

more easily, the Malay and Chinese traders concluded that they had none; and all sorts of stories were told about their living continually on the wing, and being, in fact, birds of heaven, whence originated the names of "birds of paradise" and "birds of the sun" given them by the early Portuguese and Dutch writers. Down to 1760 the skins of these birds never reached Europe with feet attached to them, and the great Linnæus recorded the fact by naming the largest kind *Paradisea apoda*, or footless bird of paradise, a name by which it is still known among men of science. The natives also generally cut off the wings, so as to give greater prominence to the ornamental feathers; and this gives the birds an altogether different appearance from what they really possess in a living state, or when properly preserved.

By far the greater number of these birds, and those of the richest colors and most remarkable plumage, live on the mainland of New Guinea, and they are especially abundant in the mountains of the northwestern peninsula, where the Italian and German naturalists already referred to obtained fine specimens of all the known kinds. In the southeast one new species has been discovered, but only two or three sorts are found there; and as they are also in little variety in the lowland districts of the northwest, it becomes pretty certain that they are more especially mountain birds. We may therefore confidently expect that, when the great ranges of the interior are visited and explored by naturalists, other and perhaps still more wonderful species will be discovered. It is interesting to note that, with the exception of one very peculiar species discovered by myself in the Moluccas, all the birds of paradise are found within the hundred-fathom line around New Guinea, and therefore on lands which have probably been connected with it at a comparatively recent period.

Why such wonderful birds should have been developed here and nowhere else is a mystery we shall perhaps never completely solve; but it is probably connected with the absence of the higher types of mammalia, and with the protection afforded by luxuriant equatorial forests. The only other country in which similar strange developments of plumage and equally superb colors are found is equatorial America, where somewhat similar conditions prevail, and where mammalia of a low grade of organization have long predominated. Whatever may be the causes at work, their action has not been restricted to the paradise-birds. Nowhere else in the world are *pigeons* and *parrots* so numerous and so beautiful as in New Guinea. The great crowned pigeons, the largest of the whole family and rivaling the largest game-birds, were first described by Dampier as "a stately land-fowl about the size of the dunghill cock, sky-colored, but with a white blotch and reddish spots about the wings, and a long bunch of feathers on the crown." Many of the fruit-doves are strikingly beautiful, being adorned with vivid patches of crimson, blue, or yellow, on a pure green ground. Parrots are wonderfully varied, including the great black and the white

cockatoos; the lories, varied with crimson and purple, green, yellow, and black; while there are strange little crested green parrots no larger than our blue tit—the smallest of the parrot tribe, as the great black cockatoos are the largest. Kingfishers, too, are remarkably abundant, and include several of the fine raquet-tailed species, with plumage of silvery blue, and with white or crimson breasts. Many other groups of birds are also adorned with exceptionally gay colors; and a careful comparison with the birds of other countries shows that nowhere in the world is there so large a proportion of the whole number of species adorned with brilliant hues. Among insects the same thing occurs, though not in quite so marked a degree; yet the superior beauty of many groups of beetles over the corresponding groups in Borneo is very distinct; and the same is to some extent the case with the butterflies and moths.

Independently of the beauty and singularity, the great number of species of birds inhabiting New Guinea is very remarkable. Considering that there are no resident collectors in the island, and that our knowledge is wholly derived from travelers who have spent a few weeks or months on the extreme northern or southern coasts only, leaving the great mass of the interior wholly unexplored, the number of land-birds already known (about four hundred species) is surprising. It is very much greater than the numbers inhabiting the whole of the West Indian Islands, or Madagascar, or the large, rich, and comparatively well-explored island of Borneo. Even Australia, so much more extensive and so varied in climate and vegetation, has only four hundred and eighty-five land-birds; and when we consider that the central mass of New Guinea, with its lofty mountain ranges and fine upland valleys, yet remains absolutely unexplored, it is not improbable that the birds of this wonderful island may be eventually found to be as numerous as those of its parent continent. We may therefore safely assert that in no part of the world has the naturalist such a certainty of making new and important discoveries as in the still unexplored regions of central New Guinea.

The peculiar race of mankind inhabiting this great island attracted the attention of the earliest voyagers, and the country was called New Guinea from the resemblance of its inhabitants to the negroes of Africa, removed from them by nearly one third the circumference of the globe. The early writers, however, term the people Papuas or Papuans, a Malay term given to them on account of their woolly hair, so different from the perfectly straight hair of almost all the other Eastern races. The Malay word "papuwah" or "puah-puah" means frizzled like wool; and the Malays still call these people "orang papuwah"—woolly-haired men, and the island itself "tana papuwah"—the land of the woolly-haired.

It is a very remarkable fact that woolly-haired people should be

found in two such widely separated areas, and, with very few exceptions, nowhere else in the world. In Africa they occupy the larger portion of the continent, extending over all the tropical and southern regions; while in the East they are found only in a group of islands of which New Guinea is the center, extending westward as far as Flores and eastward to the Feejees. There are also a few outlying groups of woolly-haired people, which are of great importance as indicating that this type once had a wider extension than now. In the Pacific we have the now extinct Tasmanians; and far to the east, in the midst of the brown Polynesians, we find the inhabitants of Penrhyn's Island and Mangaia, in about 158° west longitude, to be of the Melanesian or dark race. In the Philippines there is an aboriginal race of woolly-haired dwarfs—the Aëtas or Negritos; and a similar descriptive term may be applied to the Semangs of the Malay Peninsula, and to the natives of the Andaman Islands in the bay of Bengal. These various Eastern tribes differ among themselves quite as much as do those of Africa. Both agree, however, in being usually very dark-skinned, and examples may be found in which negroes and Papuans are in all respects very much alike. But this is exceptional, and there is almost always a characteristic difference which would cause most of the Eastern negroes to appear out of place on the continent of Africa. The woolly hair, however, combined with the dark skin and almost always with a dolichocephalic or long skull, so markedly distinguishes all these people from the rest of the inhabitants of the globe, that it is impossible not to look upon them as being really related to each other, and as representing an early variation if not the primitive type of mankind, which once spread widely over all the tropical portions of the eastern hemisphere. Successive incursions of the lighter-colored, smooth-haired races seem to have exterminated them in many of the areas they once inhabited, while in some widely scattered spots a few scanty remnants continue to exist. Two important groups, however, remain predominant in regions very far apart, but each well suited to their vigorous development. The negro of Africa has been made the servant of the more civilized races from the earliest periods of history, and is better known to us than any other uncivilized people; while the Papuan or Melanesian, inhabiting a group of tropical islands on the other side of the globe, still remains a mere shadowy name to the great majority of English readers. We proceed now to point out the chief physical and mental characteristics, habits, and customs of this interesting race as it exists in New Guinea, with occasional references to such modifications of it as occur in the other islands.

We now possess trustworthy descriptions of the Papuans as they exist at numerous localities scattered all round the extensive island they inhabit; and the substantial agreement of these descriptions renders it pretty certain that all belong to one race, exhibiting, it is true, considerable variations, and occasionally presenting undoubted

signs of intermixture with other races, but always showing a decided predominance of true Papuan characteristics. In stature they present a medium between the short Malays and tall Polynesians, the average height varying at different parts of the coast from five feet two to five feet eight inches. Some tribes in the interior are believed to be as dwarfish as the Negritos of the Philippines, while others are nearly equal to the tall Feejeeans, who are often considerably over six feet high. They are strong and muscular, but rather less finely formed than many of the Malayan and Polynesian tribes. Their color is usually a chocolate-brown, sometimes almost black, at others almost as light as some of the Malays. It is, however, by their features that they are best distinguished from all other races of men, and especially by the form and size of the nose. This is always large and long, usually arched as in the Jewish type, and, when well developed, with the extremity so lengthened as to hide the nostrils and overhang the upper lip. This peculiar characteristic is found more or less developed everywhere round the coast of New Guinea, so that almost every traveler speaks of the "Jewish features"—the "aquiline" or "arched" or "very prominent" noses—or makes use of other similar expressions, clearly showing that this is the typical Papuan feature, a fact which is further demonstrated by the unmistakable though exaggerated manner in which it is represented in all their images and carvings. The nose is also very thick and coarse, as is the case in almost all savage races; the alæ are very oblique, and the base is much depressed between the eyes, a character which reaches its maximum in the natives of New Caledonia and the New Hebrides, though the nose itself is with them somewhat shorter. The forehead is rather flat and retreating, the mouth large, and the lips full but not excessively thick; nor is there any marked prognathism. The combination of these peculiarities in various degrees produces faces which are sometimes ugly and savage-looking, while others have so much the character of the Jew or Arab as to be really handsome. Comparing Papuans with typical negroes of equatorial Africa we find a radical difference in the small flat nose and very prominent jaws of the latter. In the South African races this difference is less pronounced. The Bechuanas and Natal Caffres have less prognathism and a straighter, better-formed nose, but this organ is always shorter and less arched than in the Papuan. The Hottentots have often well-formed features and sometimes have a considerable resemblance to the less typical Melanesians. The greatest resemblance, however, is to be found between the Negritos of the Philippines—who have short flat noses and somewhat projecting jaws—and some of the dwarfish tribes of Central Africa.

The Papuan contrasts strongly with Malays and Polynesians in being hairy-bodied and tolerably well bearded, but still more so by the wonderfully luxuriant growth of the hair of the head, which forms a dense mop often projecting six or eight inches from the skull. It is crisp, glossy, and very elastic, and each separate hair naturally curls itself up

into a spiral of small diameter. The degree of twist and consequent woolliness of the hair seems to be dependent on its being oval or flattened instead of cylindrical. In the straight-haired races and in most Europeans the hair has a circular section, which becomes slightly oval where it is naturally curly; but in the negro and Papuan it is much flattened, and has besides irregular wavy margins, which seem to produce the strong spiral twist. Those who possess a large mop of hair are very proud of it, keeping it continually combed out with a kind of bamboo fork, and using a narrow wooden pillow on which to rest the nape of the neck, so as to preserve the hair from being squeezed out of shape. It was long thought that the hair of these people possessed a peculiar character in growing in separate small tufts scattered uniformly over the scalp; but more accurate examination shows that it grows evenly over the surface of the head, and that the tufted appearance probably arises from the tendency of the spirally twisted hairs to mat together in small, curly locks. The hair on the body and limbs, though very short, has the same appearance and a similar structure.

The dress of these people is very scanty, the men wearing the usual T-bandage of bark-cloth, but in some cases only a shell, or even going absolutely naked; while the women always wear some kind of girdle from which is suspended a small apron of bark or a fringe of leaves. As with most savages, ornament is more attended to than dress, and is more used by the men than by the women. They often pierce the sides of the nose, sticking in them pieces of bone, feathers, or tusks of the wild pig. The ears are also pierced, and either shell ear-rings are worn, or sticks ornamented with feathers are stuck through the lobes. Necklaces of teeth or shells are common, and heavy rings of white shell or plaited bands of grass or palm-leaf are worn on the arms. The hair of the men is always carefully attended to. It is combed with a kind of bamboo fork with four or five prongs, and this is usually kept stuck in it both for convenience and ornament. Some tribes cut and trim or plait the mop of hair into various helmet-like or other fantastic shapes, and all adorn it with combs, sticks, or feather ornaments. Suspended from the neck they often wear a small carved wooden figure with the Papuan features greatly exaggerated. As they freely part with these, they are probably mere ornaments or charms rather than idols or fetiches. Regular tattooing is unknown, except on the southeastern peninsula where there is an infusion of Polynesian blood, but most of the men have raised marks produced artificially. These generally consist of a few short parallel lines on the arms or breast, and are said to be formed by gashes made with a sharp stone or bamboo, and the subsequent application of fire to make the skin swell up and leave a prominent scar. Painting the body is not generally practiced, but some kind of stain producing a blue-black tinge has often been observed.—*Contemporary Review.*

EXPERIMENTS WITH LIVING HUMAN BEINGS.

By GEORGE M. BEARD, M. D.

II.

In experimenting with living human beings, deception, whether voluntary or involuntary, can only be scientifically met by deception; it must be beaten with its own weapons. No experiment of this kind in which the results depend in any way on the honesty of the subjects experimented on can be of any value in science; and those who assume that, because the subjects of these experiments are members of great churches, and move in high society, they are therefore incapable of untruth, would do well to resign the task of investigations of this sort to those who are better endowed with the scientific sense. *Systematic, orderly, exhaustive deception*, on the part of the experimenter, as here suggested, will, in all cases, exclude both intended and unintended deception on the part of the subject or bystanders.

Sixth Source of Error: *Chance and coincidences.*—The subject of chance and coincidences seems never to have received the attention from men of science that its direct and practical bearings on experimental research and the principles of evidence would long ago have demanded. On the mathematical side the philosophy of chance has been investigated and discussed by various writers, and with not a little intelligence and skill; but with the effect also of misleading many amateur experimenters and reasoners, who have thereby been tempted to employ mathematical estimates in departments of science where they are sure to guide into error. No forms of error are so erroneous as those that have the appearance without the reality of mathematical precision. Of this sort are the blunders of those physiologists who, at various times and under various guises, have sought to solve physiological problems by experiments half built up on rigid mathematical calculations, the other half having no foundation at all; for the average non-expert observer is awed and overpowered by the very sight of figures, and assumes that an investigation into which addition, subtraction, and multiplication enter, must inevitably lead to precise and unerring results, forgetting that, as quantitative truth is of all forms of truth the most absolute and satisfying, so quantitative error is of all forms of error the most complete and illusory. Figures, to be of any value in science, must go all around the subject and thoroughly embrace it, else they fail to master it and become its possessor: for, while the truth is apparently shut in on one side, it is all the time stealthily escaping at the other. Thus it is that the most acute calculators, most logical reasoners, and most accurate observers as well, are so often cheated out of the truths to the search for which their lives are devoted; the instincts of the plow-boy often outstripping the wisdom of the philosopher.

Among this class of scientific blunders is the custom of applying the calculations of chances to experiments with living human beings. Thus in the now well-known mind-reading performances it was averred that by a mathematical calculation there would be but one chance in several hundred thousand of finding any object in a house or hall or assemblage; hence it was inferred that a new force, or manifestation of force, had been revealed to the world. The fallacies in this philosophy do not require a very long search; of the many objects in any house, or indeed in any public building, but a small minority would be accessible in any mind-reading test, and of these few only a limited number are of a sufficiently positive nature and description to be thought of by the subject of such experiments; then, in addition, are all the errors that come from intentional and unintentional assistance of audiences and bystanders.

Practically the only way to eliminate, in a scientific manner, the error of chance or coincidence in all experiments of that character, is by making comparative experiments in the same line, with all the sources of error closed except chance, and to repeat these a sufficient number of times to make an absolute domonstration. In this way it was shown that *mind-reading*, so called, was really *muscle-reading*. In these and in all studies of like character it is to be recognized that coincidences of the most extraordinary and astonishing nature are liable to occur at any instant, and that they are as likely to occur on the first trial as on the last of a long series. To determine whether any conjunction of events is simple coincidence, or the result of some new fact or law in science, is possible oftentimes only through a series of comparative experiments. In the researches which I made in muscle-reading it was shown over and over that by pure chance alone—every other element of error being excluded—the blindfold subject would, under certain conditions, find the object looked for in one case and sometimes in two cases out of twelve.

It would seem that the errors from chance and coincidence were the most patent of all the errors that complicate and confound scientific investigation, and so clear even to the unskilled and unthinking mind, that trained investigators would never be deluded by them. But in practice it vitiates the research and the philosophizing of educated men, even more perhaps than any other of the six, excepting the involuntary action of mind on body which, as we have seen, has been the stone of stumbling for physiologists ever since physiology was introduced into science.

Hay-fever, for half a century and more, has supplied an unusual richness of material for false reasoning of a similar type. An English physician, a victim of this disorder, notices that he is worse as he crosses a field of grass, and concludes that at last he has found the one source of the mystery, and so gives the affection a misleading name which it can never lose; Helmholtz, a leader both in physics and physiology, puts the nasal secretions under the microscope, discovers some

unexpected infusoria that are killed by quinine, and announces to the world in one breath a theory of the disease and a specific for its cure, without apparently suspecting, what is now known, that the presence of infusoria might be a coincidence or effect and not a cause.

To all this it may be said that practically we do find out the true value of medicines and their objective action on the human body without systematically eliminating any of the six elements of error here pointed out. This is to be allowed ; but the admission of the fact requires also an explanation of the way in which these errors are in practice actually eliminated, although unintentionally and unsystematically, and I may say also, most unscientifically.

It is by an immense number of experiments or trials on a large variety of cases, at different times, by different observers, and under varying conditions, that medical science has been able, after centuries of doubt and struggle, to arrive at some few real scientific facts in regard to the action of medicines. If these six elements of error had, from the first, been everywhere recognized and comprehended and systematically guarded against, the process of finding the truth in this department might have been abridged by hundreds of years. The method by which, in practice, physicians learn the action of any new remedy, is to give it to a number of cases, and then to watch and report the results ; another physician repeats the experiments on a different set of cases ; he also notes the results: and this process goes on perhaps for years, until in lapse of time the profession, without being able to give precise and convincing reasons for their faith, slowly and instinctively settles down to the persuasion that the effects claimed for the remedy are genuine, and act accordingly.

In many instances they are right in this conclusion ; but how awkwardly and in what a roundabout way, and through what useless and wearying toil, have they, in doubt and distrust and suspicion, finally reached that goal ! All the trials with the remedy, from beginning to end, have been impaired in scientific value by some one or all of the six elements of error ; but through the immensity and variety of the experiments, extending through a long period, these errors have been *unconsciously* and *unwittingly* eliminated, so that only the solid fact is left. This unconscious elimination or rather leaving behind of errors, after the analogy of the formation of the universe according to the nebular hypothesis, takes place in this manner: In the first hundred cases treated there will be perhaps one or two, or more, who have no faith in and no expectation from it, good or bad ; these few obtain the real objective effects of the remedy, while all the others deceive, more or less, themselves and their physician. In subsequent experiments by other observers, some of whom perhaps are less hopeful than the original investigator, the same unconscious and irregular elimination takes place, until the objective power of the remedy may for all practical needs be regarded as established. Such is the history and philosophy of medical experi-

mentation in all ages and with all schools of medicine I claim that by the rigid following out of the principles here taught it will be possible for even the humblest member of the profession to take any new remedy, and, if a sufficient number of cases be provided, to accurately determine some points at least of its therapeutic value, if it really possesses any that are capable of being demonstrated to the senses or reason of man. It is the unconscious or unformulated apprehension of these errors in the working up of remedies that causes so many of the profession to take at certain periods of their lives the extreme and unscientific view that all medication is a mistake—that drugs have no power outside of the mind of the one who takes them—and consequently, and logically, to trust only to the forces of nature and hygiene.

In relation to this branch of our theme, it is worthy of note that there are certain modes of treating disease which from the very nature and manner of their employment can not be experimented with in a truly scientific way; it is impossible to use them so as to deceive the patient on whom they are used; of necessity, therefore, they must be developed by the process of successive eliminations already described. Among the medical procedures of this class are hydro-therapeutics or hydropathy, electro-therapeutics, and massage, or systematized rubbing, kneading, and manipulation; none of these remedial operations can be used without the patient's knowledge; none of them can be used in a different way from what the patient supposes they are being used; they are open, in clear sight, and affect the various senses so strikingly that satisfactory deception is impossible; patients know when they are being galvanized or faradized; they know when they are washed or showered; they know when they are rubbed and kneaded; no art or device of the physician can avail to so deceive them as to absolutely eliminate the error that comes from the hope or fear or expectation of what the treatment is to accomplish. The practical value of these methods of treatment—and they are all of undoubted value—could only be ascertained, as it has been ascertained, by the immense variety of the experiments that have been made with them, wherein through the process of time the six sources of error have been little by little eliminated.

In all new remedies and systems of treatment the aim of the scientific physician should be to make the deception so thorough that whatever effects are obtained must be known positively to be the objective action of the treatment or of nature. The criticism which I make on Burq, Charcot, and others, who have recently experimented with the action of metals of different kinds on the anæsthesia of hysterical patients, is that they left the question open when, by a systematic, orderly, and thorough provision against these six sources of error, they had it in their power, with the vast material at their command, to have absolutely closed it; if they could not determine with certainty whether the temporary disappearance of the anæsthesia on the application of

plates of copper or silver or gold was the result of feeble electrical currents excited, or of simple mechanical pressure, or of absorption, they could surely have answered, to the satisfaction of scientific men, the question whether it was to be explained subjectively or objectively; but this, through want of appreciation of the sources of error, or from want of a formula to guide them in their elimination, they failed to do. Even though it should be proved, as it may be, that some of these phenomena observed by Burq, and Charcot, and Westphal are objective, and independent of the expectation of the persons operated on, the validity of this criticism is thereby not at all affected. To attempt to build up a practice of metal-therapeutics on the basis of metalloscopy as that claim now stands, is like putting up a house before we are sure of our foundations. The first question to decide is whether metal-therapeutics is or is not really mental-therapeutics.

In the illustrations for this essay I have chosen, by preference, the experiments of scientific men of skill, honor, and distinction, and for the same reason that Blair, in his work on rhetoric, refers, for examples of incorrectness, inelegance, and carelessness of style, only to the writings of the greatest masters of style in the language: if these things be done in the green trees, what shall be done in those that are utterly dry? The average scientist, the every-day physician, the followers, the gleaners and popularizers of knowledge, are expected to blunder and teach but half truths, if not positive error; but if all those who should be our experts fail us, where can we look for clear ideas? It is no overplus of enthusiasm, no fancy of rhetoric, to say that if these six sources of error and the true methods of providing for them had been mastered half a century ago, the history of scientific experimenting during that time would have been radically different from what it now is.

On this subject no nation can throw stones at another; in all the great centers of modern civilization the strongest leaders of science and scientific thought have been and are constantly demonstrating their non-expertness in the art of experimenting with living human beings; the history of science, or the demonstrably true, and the history of delusions, or the demonstrably false, run in the same channels; but in the minds of the French there appears to be some psychological peculiarity that, while it urges them to undertake, at the same time unfits them to succeed in researches of this character, their very genius for science, as it relates to inanimate nature and the lower forms of life, predisposing them to all error when dealing with living human creatures; hence the paradox of history that France is at once the home of science and the home of delusions. Now, for almost a century, the ablest philosophers and experimenters of France have been wrestling with the problem how to experiment with living human beings; from the first committee of the French Academy on mesmerism, through Perkinism and Burqism, down to the very latest bulletin of Charcot on metalloscopy, it is one uniform, unbroken record of per-

severing non-expertness and failure: Science constantly baffled, beaten, utterly overthrown, yet as often returning to the hopeless contest, where delusions always compel a drawn battle, if they do not positively win; experiments without number that have the form of precision without its substance; all truth, or even the suggestions of truth, submerged in vast floods of error; the faith that belongs to religion and emotion carried into the realm of science and intellect; all along the line of strong endeavor an obvious want not only of the philosophy but even of the instinct of seeking truth from living human beings—in the whole history of folly one shall not find a more instructive chapter than this; were there no other proof of the limitations of the human brain, sufficient could be found in this fruitless searching after truth on the part of the most intellectual leaders, of the most intellectual of nations, in the most intellectual era of the world. Not only during the past year, in the hospital of Salpêtrière, but, by recurring intervals, during the past century, the best science of France has been on its knees before hysterical women, and there it must remain until it has mastered the true philosophy of trance and the involuntary life, and learned by heart the sources of error.

The time must come when it shall be well understood that experiments with living human beings, in which the elements of error are unrecognized, are not only unscientific but are a satire on science; bearing the same relation to the true method of investigation in this special department of physiology that the dreams of the mediæval sages sustained to the general philosophy of induction. The philosophy of the future will be that the laws of nature are not to be put on the market, and can not be bid off at auction, and that the long-standing and unaccepted financial prize of the French Academy for the one who should prove to be endowed with clairvoyant or mind-reading power is as unscientific and as puerile as to attempt the bribery of the law of the conservation of force, or to hire the sun to rise in the west instead of the east.

During the past few years it has been my destiny to have been frequently requested to carry out or to plan for others various experimental researches with living human beings; these requests have sometimes come from professional and scientific men who, in all dealings with inanimate objects, are amply competent, both by instinct and by reflection, to guard against all illusions and deceptions. It is my hope and belief that this formal attempt—ill perfected as it may be—will so reduce this subject to a science as to bring it within the power of all physiologists to plan and to complete all such experiments for themselves, with ample confidence that the results will invariably be in harmony with the truth. The above analysis, in spite of its necessary condensation, will, it is hoped, make clear even to those who do not follow all its details, that in this, as in every other realm of knowledge and acquirement, success need not be the result of any special acuteness, or

cunning, or wisdom, but can be made the possession of any sober and well-trained mind that has a sufficient endowment of the scientific sense to recognize and submit to the inevitableness of law in all mental as in all physical phenomena, and to subordinate, even in scientific research, all feeling and emotion to intellect and reason.

The relation of this subject to delusions is also of much interest, both psychological and practical; during the present century especially the prevailing follies of civilization have received an unusual and unprecedented dignity and strength from the non-expert experiments of scientific men with living human beings. It is a part of the inconsistency of ignorance, and one of the effects of long breathing the atmosphere of superstition, that the apostles of the demonstrably false, while they uniformly dread and oppose the advance of their natural enemy, organized knowledge, yet pray for and welcome all mistakes of scientific men, either in experiment or philosophy, as so much addition to their capital; the weapons with which delusionists of every name prefer to fight their battles are forged in scientific armories; trace any one of the rank and overrunning superstitions of our day to its utmost radicle, and it will surely lead to sources where we are wont to look for light and truth—to some great discovery which our chemists, our naturalists, our astronomers, of fair and noble fame, have evolved, or are believed to have evolved, out of experiments that they have made, or tried to make, with living human beings; to the laboratory of some physiologist even, who forgets that the chief fact in human life is the involuntary life; to some logician and philosopher, who has yet to learn that the habit of trusting the senses, though endorsed and inculcated in all the universities of the world, is the source of half the ignorance and not a little of the suffering of mankind.

SHALL WE ADOPT THE METRIC SYSTEM?

DURING the second session of the Forty-fifth Congress, a great amount of evidence bearing on the question whether or not it would be wise to introduce the metric system into the United States was brought forward. This evidence is given in reports, etc., from the heads of the various executive departments, and the most important bureaus of the Government, and it is likely to remain buried in the vast mass of fugitive public documents known only by the "printer's number."

The editor has been at some pains to collect the scattered pieces and reports, and to put them into a continuous if not a connected form, with the object of making them available for reference in future. This it seems amply worth while to do for various reasons; chiefly because

these contributions to the solution of the really important question at the head of this article have a unique and special value. They have been written by officers high in position in the Government and entirely free from prejudice. Their recommendations were not influenced by any considerations as to their personal convenience, and their judgments were based on the actual operations of their several departments. It is somewhat singular, in examining their reports in detail, to find that there is so little repetition. For these reasons it appears that no such important additions to the literature of this subject have been made for many years. In what follows, brevity has been studied, and omissions have been freely made whenever possible, the object being to present only the most important arguments. The bills introduced into Congress are first given, and then follow the detailed reports of the heads of executive departments. No attempt has been made to answer the important questions considered, that having been left to the reader.

Mr. Muldrow introduced on November 3, 1877, a bill "to promote the establishment of the metric system of coinage in the gold coins of the United States of America.

"*Whereas*, The metric system of coinage, based on the gramme as the unit of weight, is now almost universally acknowledged to be the best; and—

"*Whereas*, The gold coinage of the United States can be brought into exact conformity with the metric system by a change amounting to less than one third of one per centum: therefore—

"*Be it enacted*, etc., That the gold hereafter coined by the United States shall contain, for each dollar of denominational value, one and one half gramme of pure gold, and shall weigh, for each dollar, one and two thirds gramme, the proportion of alloy to the entire weight being thus kept as one to ten.

"Section 2. That such coins shall be legal tenders in payments arising from contracts made at any time after the 4th day of July, 1878.

"Sec. 3. That such coins shall have stamped upon them, in addition to other devices, their weight in grammes, and the inscription, 'nine tenths fine.'"

Mr. Maish introduced on January 25, 1878, a bill "to establish the metric system in the post-offices and custom-houses of the United States.

"*Be it enacted*, etc., That on and after January 1, 1879, for all postal purposes, fifteen grammes shall be substituted for half an ounce, and so on in progression.

"Sec. 2. That on or before January 1, 1879, the Postmaster-General shall furnish all post-offices with postal balances denominated in grammes of the metric system, at an expense," etc., etc.

"Sec. 3. That on and after January 1, 1880, the metric system of weights and measures, as legalized in section 3,569 of the Revised Stat-

utes shall be *obligatory* in the assessment of duties on imported commodities in the custom-houses of the United States."

Mr. Stephens introduced, January 29, 1878, a bill "to enable importers to use the metric weights and measures."

"*Be it enacted*, etc., That the *ad quantum* duties upon all articles imported from foreign countries which are invoiced according to the weights and measures of the metric system shall be levied, collected, and paid at rates appropriate to the weights and measures of said system, that is to say:

"The rate per gramme shall be," etc. . . .

"The rate per kilogramme shall be," etc. . . .

"SECTION 2. That the quantity of weight, gauge, or measure stated in the return of any weigher, gauger, or measurer employed in the service of the customs revenue may be stated in metric denominations," etc., etc.

Mr. Stephens introduced, March 29, 1878, a bill "to promote the general use of the metric system."

"*Whereas*, The metric system of weights and measures has made little progress in actual use, notwithstanding its great merits and its authorization by law, by virtue of the act of Congress of July 27, 1876; and—

"*Whereas*, It is believed to be capable of simplification, so as to remove many impediments to its general use, yet retain its valuable features, and so to promote the great and desirable reform contemplated by the foregoing act: therefore—

"*Be it enacted*, etc., That the use of the modified metric system, set forth in the following tables marked A, be, and is hereby, authorized; the values of the metric units, so far as they are retained, remaining unchanged, and the continued use of any system now permitted by law not being prohibited, the true intent and meaning of this act being not to enforce any particular system, but to provide for the public convenience by adaptation to its circumstances and exigencies.

"SECTION 2. The metric system being capable of indefinite expansion to suit the ever-enlarging uses of mankind in business and science, the accompanying scale of units, names, and values is provided, marked B, on the scale of ten and its powers, and the use of all and any of them is hereby permitted and authorized.

A.—METRIC TABLES.

MEASURES OF LENGTH.

100 hairs make a nail.
100 nails make a metre.
1,000 metres make a kile.

MEASURES OF SURFACE.

10,000 square metres make a great acre.

MEASURES OF BULK AND CAPACITY.

100 drops make a spoon.
100 spoons make a quart.
100 quarts make a cast.

MEASURES OF WEIGHT.

100 seeds make a corn.
100 corns make a nut.
100 nuts make a bi-pound or bip.
1,000 bips make a ton.

B.—TABLE OF METRIC UNITS.

MEASURES OF LENGTH.

Ratio to next unit.	Metric name.	New name.	Value in English measure.
100,000..		Atom unit	Inch.........0·00000000003[illegible]
10..		Heat wave	Inch.........0·00003937
10..		Spider's web	Inch.........0·0003937
10..		Hair	Inch.........0·003937
10..	Millimetre	Pin	Inch.........0·03937
10..	Centimetre	Nail	Inch.........0·3937
10..	Decimetre	Hand	Inches.......3·937
10..	Metre	Metre	Inches......39·37
10..	Decametre	Half-chain	Feet........32·809
10..	Hectometre	Bow-shot	Yards......109·363
10..	Kilometre	Kilo	Mile.........0·62138
1,000..	Myriametre	Bi-league	Miles.........6·2138
10,000..		Earth quadrant	Miles.....6,213·8
		Orbit unit	Miles.62,138,200·

MEASURES OF SURFACE.

Ratio to next unit	Metric name.	New name.	Value in English measure.
100.....	Centare	Square metre	Square yards........1·196
100.....	Are	Square half-chain	
100.....	Hectare	Great acre	Acres..............2·47114
		Square kilo	

MEASURES OF BULK AND CAPACITY.

Ratio to next unit.	Metric name.	New name.	Value in English measure.
10......		Drop, $\frac{1}{160}$ cubic inch	Cubic inch........ 0·0061
10......	Millilitre	Die = Nail cube, $\frac{1}{16}$ cubic inch.	Cubic inch........ 0·0610
10	Centilitre	Spoon, $\frac{5}{8}$ cubic inch	Cubic inch........ 0 6102
10......	Decilitre	Wineglass	Cubic inch........ 6·102378
10......	Litre	Quart = hand cube	Cubic inch........61·023378
10......	Decalitre	Pail	Pecks............ 1·135
10......	Hectolitre or decistere	Cask	Wine-gallons......26·418635
	Kilolitre or stere	Metre cube	Cubic feet........35·31658 Or, bushels........28·3742

WEIGHT.

Ratio to next unit.	Metric name.	New name.	Value in English measure.
1,000....	....	Gas unit, $\frac{1}{70000}$ grain	Grain........... 0·000015
10....	Milligramme.	Seed = pin cube, $\frac{1}{70}$ grain.....	Grain............ 0·0154
10....	Centigramme	....	Grain............ 0·1543
10....	Decigramme.	Corn = drop, $1\frac{1}{2}$ grain........	Grains........... 1·5432
10...	Gramme....	Die = nail cube.............	Grains..........15·43235
10....	Decagramme.	Nut, $3\frac{1}{2}$ ounces..............	Ounces.......... 3·5276
10....	Hectogramme	....	....
10....	Kilogramme..	Bip = hand cube, $2\frac{1}{5}$ pounds...	Pounds.......... 2·2046
10....	Myriagramme	....	....
10....	Quintal.....	....	....
....	Millier or tonneau......	Ton........................	Pounds........2,204·62125

This system is understood to be the invention of Mr. SAMUEL BARNETT, of Washington, Georgia.

It is believed that no other bills were introduced in relation to the metric system. It is perhaps worth while to quote a bill "proposing a reward for a new foot-measure," as a sample of what may be laid before Congress:

"*Be it enacted*, etc., etc., That the Congress of the United States of America will vote an appropriation, the same as a reward, to be paid the American citizen who shall produce a new foot-measure which shall divulge, in it, the truth of the meeting of parallel lines in exceeding great length."

A resolution of the House of Representatives (November 6, 1877) provided "that the heads of the executive departments be, and they are hereby, requested to report to this House, at as early a date as practicable, what objections, if any, there are to making obligatory in all governmental transactions the metrical system of weights and measures whose use has been authorized in the United States by act of Congress; and also how long a preliminary notice should be given before such obligatory use can be introduced without detriment to the public service; and that they are also requested to state what objections there are, if any, to making the metrical system obligatory in all transactions between individuals, and what is the earliest date that can be set for the obligatory use of the metrical system throughout the United States."

This resolution addressed directly the officers best qualified to judge of the questions involved, and their answers are given below, abridged when possible.

The Secretary of State reports: 1. That the obligatory use of the metrical system, so far as the operations of the Department of State are concerned, and especially its consular and commercial relations with foreign governments, while of convenience and utility with respect to those countries which have already adopted the metrical system to the exclusion of all others, would be of no benefit with regard to those

countries which have not so adopted it, and would introduce detrimental confusion, in particular in its commercial relations with Great Britain and other countries where the system of weights and measures is the same as that of the United States, with which countries the bulk of our foreign commerce is at present carried on.

2. That should the obligatory use of the metrical system in governmental transactions be enacted, two years' preliminary notice of the change would suffice to bring the system into harmonious and uniform use in this department and its dependencies abroad.

3. That the Department of State does not seem to the Secretary of State to be in a position to express an authoritative opinion as to the obligatory adoption of the metrical system in all transactions between individuals, inasmuch as its relations directly with the people of the United States are not of a character to be either beneficially or injuriously affected by the suggested change. He ventures to remark, however, that even in those countries, like France, where the system has been obligatory beyond the memory of the present generation, the tradition of the old system clings among the people and defies complete eradication; and that in other countries, like Spain, where the metrical system is adopted in governmental transactions and legalized for those of individuals, the innovation is practically disregarded by the people and but partially conformed to by the Government, which is compelled to recognize the validity of the old standards, in which the continuing transactions of the nation, such as the registration of landed property, the assessment of industrial taxation, etc., are still, and must be of necessity for many years, recorded. While recognizing that the proposed measure is one mainly affecting the people, and therefore properly to be legislated upon by the popular representatives, the Department of State, being called upon for a specific opinion on the subject, is, on the whole, indisposed to recommend the obligatory use of the metrical system in all transactions between individuals.

4. That should its obligatory use as between individuals be enacted, a period of not less than five years should be allowed to elapse before the act takes effect; and that even then provision should be made for the recognition of the legal validity of transactions according to the present lawful systems of weights and measures.

The Secretary of the Navy reports: "If it were desired to make the metrical system of weights and measures obligatory in all government transactions, the Navy Department perceives no objection to it except in so far as it regards the soundings given on charts. If it were applied to these, it would probably involve a total loss of all charts and chart-plates now in use. The alteration of these would give them no increased value; and as long as English charts remain in fathoms and feet it would be in fact prejudicial, and prevent that free use and interchange of charts which seem essential to navigators.

"So far as this department is concerned, no longer notice would be

necessary than was sufficient to furnish the standard weights and measures adopted for government use.

"Respecting the last inquiry submitted by the resolution, 'What objections there are, if any, to making the metrical system obligatory in all transactions between individuals, and what is the earliest date that can be set for the obligatory use of the metrical system throughout the United States?' the department is unable to give a definite answer, inasmuch as it is not informed as to the present intention of the English-speaking peoples in regard to the adoption of the proposed change. However desirable or advantageous in theory the change might seem, if adopted by us and not by the other peoples speaking the English language, it would seem probable that a mutual disadvantage would exist growing out of diverse weights and measures.

"It may be assumed that a more general intercourse will exist between peoples speaking a common language than between peoples who speak different languages. And looking at the present geographical extent of the countries wherein the English language is used, and the importance of their commercial intercourse, and also its future importance, as compared with any other of the spoken languages, at a period not at all remote, if regarded historically, it would seem to be of doubtful expediency to separate ourselves from what is now common in weights and measures with other people who speak our language, and with whom it is desirable to increase rather than diminish our commercial intercourse. Experience would indicate that we should hold ourselves in accord with them, rather than adopt other standards, however theoretically advantageous, for it will be impossible to escape many practical disadvantages if our standards vary from theirs, so long as our intercourse shall continue."

The Postmaster-General reports as follows: "In reply to the request contained in the resolution of the House of Representatives, I have to say that the only objections to making the use of the metric system of weights and measures obligatory throughout the domestic postal service, which occur to me as having been made or as likely to be made, are two: one based on the expense incident to the change of systems, and the other based on an apprehension that the practical workings of a new system will fail to give satisfaction, owing to the lack of knowledge of the metric system and experience in its use and application on the part of postmasters and of the public at large.

"In order to ascertain the probable force of the first objection, I have caused an estimate to be made of the probable number, grade, and cost of the balances and scales of the metric system which should be provided to take the place of those now in use in case a change is ordered. The estimate is that the sum of $124,788 would be called for as an immediate outlay to provide for the change.

"In regard to the second objection, it is not to be denied that the metric system of weights and measures corresponds in principle with

the decimal system long in use in the United States for coinage and money valuations, and that presumptively no greater inherent difficulty is likely to be encountered in the application of the decimal system to our weights and measures in the domestic postal service than was met in the change from the English system of coinage and money valuations to the present one. The latter is certainly the simpler one, and has for some time past been in use for the foreign mail service of this department. The objection, then, is in my opinion founded on an apprehension that mistakes, and consequently resulting annoyances, and possibly losses, would occur in the practical application, and not on any well-grounded objection to the principle of the metric system. This apprehension would, I believe, be greatly lessened, if not altogether abated, were sufficient time given for familiarizing postmasters and the general public with the practical workings of the new system before discontinuing the use of the old one.

"I have only the same means that any other citizen has of forming a judgment in regard to the last inquiry made in the resolution of the House, and I therefore deem it proper not to attempt to make an answer to it in this connection."

The Secretary of War replies by forwarding the reports of his chiefs of bureaus.

The Inspector-General reports: "Although I have had no practical experience in the use of the metrical system of weights and measures, yet, in my judgment, the compulsory change from the present system would be inexpedient, as involving a large outlay of money without adequate comparative results."

The Quartermaster-General reports: "In reply to the reference of the resolution of the House of Representatives of the 6th instant, in regard to the objections which may exist to making the use of the metric system of weights and measures obligatory, first, in all government transactions, and, second, in all transactions between individuals, and the length of preliminary notice desirable before such metric law goes into operation in the United States, I have the honor to say that if the law makes the use of the metric system obligatory in all government transactions it can be adopted by officers of the Quartermaster's Department as soon as notified by general orders.

"Such an order can be distributed to every military post within the space of one month from the time of its publication, and, if the telegraph be used, within one week.

"The objections thereto which at once occur to me are:

"1. It will very considerably increase the labor of computation, for, in practice, all sellers to the United States will make their deliveries in accordance with the English measures now in general use, and the officers, using the ordinary scales for weight, and the yard, foot, and inch, and bushel, gallon, quart, and pint for measures, will first ascertain the quantities and sizes in the present weights and measures, and then, by

the use of tables to be distributed, will reduce them to metric quantities in their statement of their vouchers, receipts, and accounts, which will, it appears to me, be a perfectly useless labor.

"2. This reduction, involving additional calculations and transfers from one set of units to another, unfamiliar and much less convenient, will infallibly be the source of many mistakes, to the loss of the disbursing-officer of the Treasury, or of the person who sells supplies to the United States.

"3. It will be necessary, in order to make the operation of such a law really successful, to throw away all the hay-scales and other platform-scales whose beams are now divided according to the American standard units of weight, and all the rules and measures divided according to the yard, foot, and inch, and all the weights, pounds, ounces, or grains, of avoirdupois, troy, and apothecaries' weight, and to purchase, distribute, and substitute new scales and new weights according to the metric system. These changes will be expensive. The trouble and labor I do not speak of, as such labor will, in case of the passage of a law, simply be the duty of all officers and employees of the United States.

"4. If the metric system is made obligatory in government transactions and not in transactions between individuals, then continual confusion and misunderstanding will be caused by the use of one standard by the Government and another by the people. All packages are put up by merchants, manufacturers, and producers in accordance with the actual legal standards, pounds, ounces, grains, yards, feet, inches. The transactions of the United States, large as they are, are insignificant compared with those of private trade. Manufacturers and consumers, and the people, will not change their customs at the call of the officers of the United States.

"In regard to making the metric system obligatory in transactions between individuals:

"1. I do not believe that this is within the power of Congress. It will be looked upon by the people as an arbitrary and unjust interference with their private business and individual rights, and I do not think that they will submit to it. It will inflict, if it can be enforced, a great loss upon many, especially upon manufacturers and mechanics whose shops are filled with costly tools, standard gauges, dies, and machines, all constructed upon the basis of the foot and inch.

"Every geared lathe in the United States depends upon a screw of a certain number of threads to the inch, and all the screws it produces are gauged in pitch and diameter by the inch.

"The metre is not commensurate with the inch, foot, or yard; all reductions are approximate only. The law of July 27, 1866, makes the use of the metric system permissive, legal, but not obligatory, and establishes for the reduction of metres to inches, and the reverse, the ratio of one metre to thirty-nine and thirty-seven hundredths inches, which is not absolutely correct. To alter all this machinery, to change

all these machines, gauges, dies, screws, and other parts of engines, will be the work of years—will cost millions of dollars.

"The metric system is not a convenient one for common use. Its measures are not of convenient length. The yard, half the stature of a man, is of convenient length to handle, to use, to apply. It, and the goods measured by it, can be halved, quartered, subdivided into eighths, sixteenths, thirty-seconds, sixty-fourths, etc.; or it can be with equal facility divided into tenths, hundredths, thousandths. Half a metre is no dimension; half a centimetre is an unknown quantity; but half a yard, half a foot, half an inch, half a bushel, one fourth of a bushel, of a quart, of a pint, etc., are recognized. If half a litre, of a decilitre, or a quarter, eighth, or sixteenth of these quantities is provided for, then the metric decimal system is abandoned at once.

"In calculation the metric system applies admirably to money and accounts of money; but even here the Government has been obliged to abandon for the convenience of the people the true, strict, decimal system, and to coin half a dollar, half an eagle, the quarter of a dollar, etc.

"In the use of weights and measures, however, there are not so great advantages in the decimal system. The unit is too large, and the numbers produced and used in the calculations of the engineer are tedious to write and are beyond the limits of ready apprehension.

"The ciphers and figures 0·00000073 convey no idea to a mind trained in the English and American system, and yet such combinations are common in French works of science and mechanics.

"The true scientific natural basis of the metric system has been abandoned. The metre was intended and enacted to be the ten-millionth of the quadrant of the terrestrial meridian of Paris. In the progress of geodesy and science, it is ascertained that the standard metre bears no (exact) relation to that quadrant, and, though it is probably very nearly the ten-millionth of the quadrant of the meridian in which New York lies, it is not probable that it is the ten-millionth of either of the three other quadrants of that meridian, or of any quadrant of any other meridian.

"The fact is, that the metre is quite as arbitrary and unscientific a standard as the foot or yard. It is of less convenient length than either of them, and its compulsory adoption would derange the titles and records of every farm and of every city and village lot in the United States; would put every merchant, farmer, manufacturer, and mechanic to an unnecessary expense and trouble, and all, it seems to me, for the sake of indulging a fancy only, and a baseless fancy, of closet philosophers and mathematicians for a scientific basis of measures and weights which (as the metre is not a ten-millionth of the Paris quadrant, is not what it professes to be and was enacted to be) can not be found in the French metric system.

"1. The unit of length: The metre is 3·280890 + feet, or 39·37079 + inches.

"2. The unit of area: The are is 119·60332+ square yards.

"3. The unit of liquid measure: The litre is 0·26418635+ gallon, or 1·0567454+ quart, or 2·1134908+ pints.

"4. The unit of space: The stere is 1·308764+ cubic yard, or 35·386636+ cubic feet.

"5. The unit of weight is: The gramme = 15·43234874+ grains troy.

"6. The unit of roods is: The kilometre = 1,000 metres = 0·62138+ mile.

"7. The unit of land-measure for farms and city lots is: The hectare = 2·47114+ acres.

"8. The commercial unit of weight is: The kilogramme = 1,000 grammes=2·20462125+ pounds avoirdupois.

"What will our farmers, citizens, merchants, tradesmen, and mechanics do with these figures? And will they submit to being obliged to reduce acres, feet, inches, pounds, and ounces by multiplying or dividing by the above figures?

"I think that to make the French metric system obligatory between individuals in this country will be an impolitic and arbitrary interference with the rights, interests, and habits and customs of the people."

The Surgeon-General reports: "In compliance with instructions from your office calling for reports as to objections to making the use of the metrical system of weights and measures obligatory in all government transactions, and also obligatory in all transactions between individuals, I have the honor to report as follows:

"1. As to the first of the questions submitted in the resolution, I feel constrained to express the opinion that the gravest inconveniences would immediately result from an attempt to render obligatory upon government officers only the use of a system of weights and measures whose units are so entirely different from those which have heretofore been, and would then continue to be, in general use among the people. I pass by the enormous difficulties which would result from compelling government officers to use a different unit for the *measures of length* from that used by the people. This would not only throw into confusion the whole system of land measurement as practiced in the United States, but would produce the most serious inconveniences from the resulting effort to use in all government works tools and machinery gauged by a different standard from those in common use. These and similar inconveniences, some of them of the most deplorable kind, would be felt so much more severely by other departments of the Government that the duty of representing the force of these objections may safely be left to them. I confine myself, therefore, in this report, to a brief statement of the disastrous inconveniences which would result to the medical department of the army from the measure in question. This measure would compel the substitution of the metric system of weights and measures in prescribing and dispensing medicines in the army for

the system of apothecaries' weights and measures at present in use by the medical profession of the United States.

"In all the medical and surgical works of any importance printed in the English language the doses are expressed in apothecaries' weights and measures. The immediate effect of compelling medical officers of the army to substitute the metrical weights and measures would be, to force them to make a series of arithmetical calculations every time they attempt to use the prescriptions or doses laid down in any medical work written in the English language. This thankless and unnecessary labor would waste much precious time, and an error might cost life. Moreover, the strength of the various medical tinctures and solutions in use in England and America has been so adjusted that the proper dose is expressed in even minims, drachms, or fluid ounces. Merely to substitute for these simple quantities the corresponding fractional numbers would be a silly waste of labor; and in order that a proper dose might be expressed in an even number of cubic centimetres, a revision of the Pharmacopœia would be necessary, and this would have to be followed by a corresponding revision of all the medical books in common use before the new Pharmacopœia could be conveniently used. In my opinion the best interests of sick officers and soldiers require that the medical staff of the army should, in all its operations, act in the most complete harmony with the medical profession of the United States, and I can not do otherwise than express my belief that the discordance in practice, which would be imposed by such a statute as is suggested, would be fraught with the most unfortunate consequences.

"2. As to the second question, while I admit that the enforced introduction of the metric system would produce less detriment to the public service if it were rendered obligatory upon the whole people than if its use were simply compelled in government transactions, I must express the opinion that great public inconvenience would result if at the present time its general use were rendered obligatory by the exercise of an arbitrary act of power. I leave to others to point out the disorders likely to result in the land measurements, the railroad interests, and the general machinery interests of the United States, in all of which the units at present employed are incommensurable with those of the metric system, so that the use of long decimal fractions in the most ordinary transactions would become imperatively necessary as the only road of escape from still greater evils. I confine myself merely to the question of the interests of the medical profession of the United States, and must express the opinion that it will be time enough when they have asked for it to impose upon that body a change which will put all their operations out of harmony with the similar proceedings of other English-speaking nations. For assuredly many of the inconveniences which would be felt by government officers, if compelled to use a system of weights and measures not used by the people, would be felt by the whole

people if they are compelled to use a system so materially different from that employed by other English-speaking people. These inconveniences would only be reduced to the minimum, if, by an international convention between the United States and Great Britain, a mutual agreement were entered into to bring the system simultaneously into use among all English-speaking people. Unless some such international arrangement can be effected, I think it would be wiser for the friends of the metric system to remain for the present content with the law which has legalized its use by those who may find it well adapted for their own particular work. If it possesses the great advantages claimed for it over the older system, its use being already authorized by law, it will gradually extend until it has crowded all others out of existence, and no further legislation than that already had will be necessary to secure ultimately its general introduction. If, however, its advantages are so far counterbalanced by its disadvantages, at some of which I have briefly hinted, that, its use having been legalized, the people will not employ it of their own accord, its enforced introduction would be a great public wrong."

The Commissary-General of Subsistence reports: "I have the honor to state in reply to the first branch of the inquiry covered by the resolution, that to make obligatory, in government transactions, the metrical or any other system of weights and measures not in use by the people, and consequently not familiar to or generally understood by them, would not only involve great confusion and great extra labor in making reductions from the system in use by the people to the system adopted for the Government, but I believe that the people would look with grave suspicion upon government transactions based on a system of weights and measures which they did not understand; and that to adopt a system exclusively for the Government would have a tendency to remove the Government further from the people, and weaken, if not nearly destroy, their confidence in the integrity of the officials and agents of the executive departments.

"To the second branch of the inquiry covered by the resolution, I would respectfully submit that I not only believe great detriment would ensue from the adoption of the metrical system exclusively for the use of the Government, but that it would be, also, inexpedient for the United States to make the system obligatory between individuals, unless in cooperation with Great Britain, with whom we are so intimately connected by language, literature, and commerce.

"The change to a new system of weights and measures, based upon units widely different from and incommensurable with those upon which the system now in use is based, must necessarily require a great effort, and should be preceded by a long period of preparation, say twenty years. Even with the most thorough preparation, the change, when made, will bring with it almost inextricable confusion and wellnigh intolerable inconvenience, however superior to the existing system the

metrical system may be by reason of its decimal character, its symmetry, and its consequent simplicity."

The Paymaster-General reports: "I believe that the eventual introduction into common use of the metrical system is highly desirable, and is fast becoming still more necessary in our intercourse with foreign nations, especially if it is destined, as seems likely, to pervade the world. The great objects attained by it will be, fixed standards, uniformity, and the extension of the decimal system, found so useful in our money standards.

"I am satisfied that it will be advisable to begin first with legislation making the metric system obligatory in certain (not in all) government transactions. In the collection of customs, in the postal system, and in fixing the rates of coinage, and in all international transactions, it should now be made obligatory from the 1st of July, 1879. I do not recommend its adoption in the land system, and in purchases for the army and navy, and for the Government, at so early a date.

"By this first proposed legislation, a stimulus would be given for the system being taught in all the schools. Thus in six years the rising generation would be initiated and accustomed to it. It would be time enough then for legislation making its use obligatory in all remaining government transactions.

"After a full trial of these measures the people might be prepared for its voluntary introduction in domestic transactions, and for legislation making it obligatory. But it is desirable that there should be no premature legislation of this last-named character, creating discontent and an unfortunate repeal of untimely laws enacted in advance of public sentiment. The preliminary measures referred to would prepare the public mind gradually for final legislation."

The Chief of Engineers reports: "The resolution presents two main inquiries: first, as to the adoption of the metric system in the government offices; and, secondly, as to its adoption in transactions between individuals.

"So far as the proposed change would affect the works carried on under charge of the officers of the Corps of Engineers, it need only be said that while any change in the ordinary and accepted standards must be an inconvenience, yet there is no other reason why the change should not be made, provided sufficient time is given for preparation. It is thought that the French metric standards should not be adopted, to the exclusion of the present standards, in this office within a less interval of time than five years after the passage of the act. This limit is fixed as the minimum, in order to allow for the proper careful manufacture, comparison, and distribution of standards, and their duplication in various forms for ordinary use, for the necessary changes in tables and formulæ, and more especially to allow a sufficient interval of time during which a practical familiarity with the new standards may be acquired, particularly by those with whom the business of the engineer

department is transacted and who are not in the public service, as well as by those not in the public service who use the maps, charts, etc., of the department.

"In regard to the compulsory use of the metric standards in the transactions of individuals, certain additional considerations present themselves. It is to be borne in mind that there is nothing in the proposed change which will in any way favorably affect the usual course of private business in this country, and that the demand for a change from the present system does not come from business men, but is made in furtherance of a project designed for the general public good in international intercourse. There is no pressing necessity for immediate change, and it would undoubtedly be better, if the change should be made, to make it by concerted, simultaneous action on the part of all English-speaking people.

"The relations of trade between this country and Great Britain are such that the adoption of new standards of weight and measure by the one without the concurrent action of the other is extremely undesirable.

"As to the general question whether it is desirable to adopt a decimal system of weights and measures, there will probably be but little difference of opinion, since its adoption will to some extent simplify existing tables, and tend to establish a uniformity of practice throughout the world. As an actual practical fact, its adoption is a matter of no immediate importance, and certainly should not be made obligatory upon individuals before it has become generally understood by being adopted in the government service and taught in all public schools.

"The French decimal metric system has been adopted and made compulsory in France, Belgium, Holland, Greece, Italy, Spain, Portugal, Germany, Colombia, Venezuela, Ecuador, Brazil, Peru, Chili, and the Argentine Confederation and Uruguay.

"Great Britain and the United States have legalized the system, but have not made it compulsory. Switzerland, Sweden, Denmark, and Austria use partial decimal systems, but with different units of length and of measure."

PSYCHOMETRIC FACTS.

By FRANCIS GALTON, F. R. S.

THERE lies before every man by day and by night, at home and abroad, an immense field for curious investigations in the operations of his own mind.

No one can have a just idea, before he has carefully experimented upon himself, of the crowd of unheeded half-thoughts and faint imagery that flits through his brain, and of the influence they exert upon his

conscious life. I will describe a few of the results of my own self-examination in respect to associated ideas.

It was after many minor trials that one afternoon I felt myself in a humor for the peculiar and somewhat severe mental effort that was required to carry through a sufficiently prolonged experiment as follows: I occupied myself during a walk from the Athenæum Club, along Pall Mall to St. James's Street, a distance of some 450 yards, in keeping a half-glance on what went on in my mind, as I looked with intent scrutiny at the successive objects that caught my eye. The instant each new idea arose, it was absolutely dismissed, and another was allowed to occupy its place. I never permitted my mind to ramble into any by-paths, but strictly limited its work to the formation of nascent ideas in association with the several objects that I saw. The ideas were, therefore, too fleeting to leave more than vague impressions in my memory. Nevertheless, I retained enough of what had taken place to be amazed at the amount of work my brain had performed. I was aware that my mind had traveled, during that brief walk, in the most discursive manner throughout the experiences of my whole life; that it had entered as an habitual guest into numberless localities that it had certainly never visited under the light of full consciousness for many years; and, in short, I inferred that my every-day brain-work was incomparably more active, and that my ideas traveled far wider afield, than I had previously any distinct conception of.

My desire became intensely stimulated to try further experiments, and, as a first commencement of them, to repeat the walk under similar circumstances. I purposely allowed a few days to elapse before doing so, during which I resolutely refused to allow my thoughts to revert to what had taken place, in order that I might undergo the repetition of the trial with as fresh a mind as possible. Again I took the walk, and again I was aware of the vast number of extremely faint thoughts that had arisen; but I was surprised and somewhat humiliated to find that a large proportion of them were identical with those that had occurred on the previous occasion. I was satisfied that their recurrence had in only a very few cases been due to mere recollection. They seemed for the most part to be founded on associations so long and firmly established, that their recurrence might be expected in a future trial, when these past experiments should have wholly disappeared from the memory.

It now became my object to seize upon these fleeting ideas before they had wholly escaped, to record and analyze them, and so to obtain a definite knowledge of their character and of the frequency of their recurrence, and such other collateral information as the experiments might afford.

The plan I adopted was to suddenly display a printed word, to allow about a couple of ideas to successively present themselves, and then, by a violent mental revulsion and sudden awakening of attention, to

seize upon those ideas before they had faded, and to record them exactly as they were at the moment when they were surprised and grappled with. It was an attempt like that of Menelaus, in the "Odyssey," to constrain the elusive form of Proteus. The experiment admits of being conducted with perfect fairness. The mind can be brought into a quiescent state, blank, but intent; the word can be displayed without disturbing that state; the ideas will then present themselves naturally, and the sudden revulsion follows almost automatically. Though I say it is perfectly possible to do all this, I must in fairness add that it is the most fatiguing and distasteful mental experience that I have ever undergone. Its irksomeness arises from several independent causes. The chief of these is the endeavor to vivify an impression that is only just felt, and to drag it out from obscurity into the full light of consciousness. The exertion is akin to that of trying to recall a name that just, and only just, escapes us; it sometimes seems as though the brain would break down if the effort were persevered in, and there is a sense of immense relief when we are content to abandon the search, and to await the chance of the name occurring to us of its own accord through some accidental association. Additional exertion and much resolution are required, in carrying on the experiments, to maintain the form of the ideas strictly unaltered while they are vivified, as they have a strong tendency to a rapid growth, both in definition and completeness.

It is important, in this as in all similar cases, to describe in detail the way in which the experiments were conducted. I procured a short vocabulary of words, and laid it open by my side. I then put a book upon it in such a way that it did not cover the word that was about to be displayed, though its edge hid it from my view when I sat a little backward in my chair. By leaning forward the word came into sight. I also took many petty precautions, not worth describing, to prevent any other object besides the word catching my attention and distracting the thoughts. Before I began the experiment, I put myself into an easy position, with a pen in my right hand resting on a memorandum-book, and with a watch that marked quarter seconds in my left hand, which was started by pressing on a stop, and continued going until the pressure was released. This was a little contrivance of my own appended to one of Benson's common chronographs. When I felt myself perfectly in repose, with my mind blank, but intent, I gently leaned forward and read the word, simultaneously pressing the stop of the watch. Then I allowed about a couple of ideas to present themselves, and immediately afterward released the stop and gave my utmost power of attention to appreciate with accuracy what had taken place, and this I recorded at once. Lastly, I wrote down at leisure the word that had been displayed, and the time shown by the chronograph to have been occupied by the experiment.

The number of words used in the experiments I am about to de-

scribe is seventy-five. I had intended it to be one hundred for the convenience of writing down percentages; but my original list became reduced by mislaying papers and other misadventures not necessary to explain. The result was, that I procured a list of seventy-five words, which had been gone through as described, on four separate occasions, at intervals of about a month. Every precaution was used to prevent the recollection of what had taken place before from exercising any notable influence. It was not difficult to succeed in doing so, because the method of proceeding is permeated by the principle of completely discharging from the mind the topics on which it had previously been engaged.

I am particularly anxious that the fairness of the experiments should be subject to no undue doubt, and will therefore add yet a few more words about it. It may be thought an impossible feat to keep the mind as free and placid as I have described during the first part of the experiment, when the great change of its attitude in the second part was imminent. Nevertheless, it was quite practicable to do so. The preoccupation of my thoughts was confined to a very easy task, viz., to govern the duration of the experiment. We have abundant evidence of the facility of this sort of operation. We all of us have frequent occasion to enter heart and soul into some matter of business or earnest thought, knowing that we have but perhaps five minutes' leisure to attend to it, and that we must then break off on account of some other engagement. Nay, we even go to sleep, intending to awake earlier or later than usual, and we do it. In the present case, after about two ideas had successfully arisen, I succeeded, almost as a matter of routine, in lifting my finger from the spring-stop, and that little act was perhaps of some assistance in helping me to rouse my consciousness with the sudden start that I desired.

Now for the results. I found, after displaying each word, that some little time elapsed before I took it in, chiefly because the process had been performed so quietly. If the word had been flashed upon a dark background in large and brilliant letters, or if some one had spoken it in an abrupt, incisive tone, I am sure that period would have been considerably shortened. Again, whenever we read a single substantive without any context or qualifying adjective, its meaning is too general to admit of our forming quickly any appropriate conception of it. We have no practice in doing so in ordinary reading or conversation, where we deal with phrases in block, and not with separate words. Hence the working of the mind is far less rapid in the experiments I am describing than on common occasions, but not much less than it was in my walk along Pall Mall.

I found the average interval that elapsed between displaying the word, and the formation of two successive ideas associated with it, to be a little less than two and a quarter seconds—say at the rate of fifty in a minute or three thousand in an hour. These ideas, it must be

recollected are by no means atomic elements of thought; on the contrary, they are frequently glimpses over whole provinces of mental experiences and into the openings of far vistas of associations, that we know to be familiar to us, though the mind does not at the moment consciously travel down any part of them. Think what even three thousand such ideas would imply if they were all different! A man's autobiography, in two large volumes of five hundred pages each, would not hold them, for no biography contains, on an average, three such sequences of incident and feeling in a page. There must therefore be, of a necessity, frequent recurrences of the same thought; and this fact was brought out quite as prominently by these experiments as by my walks along Pall Mall. They were also elicited in a form in which I could submit them to measurement.

The 75 words gone through on four successive occasions made a total of 300 separate trials, and gave rise between them to 505 ideas in the space of 660 seconds. There were, however, so many cases of recurrence that the number of different ideas proved to be only 279. Twenty-nine of the words gave rise to the same thought in every one of the four trials, thirty-six to the same thought in three out of the four trials, fifty-seven to two out of the four, and there were only one hundred and sixty-seven ideas that occurred no more than once. Thus we see how great is the tendency to the recurrence of the same ideas. It is conspicuous in the reiteration of anecdotes by old people, but it pervades all periods of life to a greater extent than is commonly understood, the mind habitually rambling along the same trite paths. I have been much struck by this fact in the successive editions, so to speak, of the narratives of explorers and travelers in wild countries. I have had numerous occasions, owing to a long and intimate connection with the Geographical Society, of familiarizing myself with these editions. Letters are in the first instance received from the traveler while still pursuing his journey; then some colonial newspaper records his first public accounts of it on his reëntry into civilized lands; then we hear his tale from his own lips, in conversation in England; then comes his memoir read before the Society; then numerous public speeches, and lastly his book. I am almost invariably struck by the sameness of expression and anecdote in all these performances. (I myself went through all this, more than a quarter of a century ago, on returning from southwest Africa, and was quite as guilty of the fault as any one else.) Now, one would expect that a couple of years or more spent in strange lands among strange people would have filled the mind of the traveler with a practically inexhaustible collection of thoughts and tableaus; but no, the recollections tend to group themselves into a comparatively small number of separate compositions or episodes, and whatever does not fit artistically into these is neglected and finally dropped. We recollect very few of the incidents in our youth, though perhaps in old age we shall think very frequently of

that little. Let any man try to write his autobiography, say between the ages of five and six, and he will find that he has exhausted everything he can recollect of that period in a very few pages. Let him meet, for the first time after very many years, with some friend of his boyhood, and talk over some interesting event in which they were both engaged, and of which his recollection is so vivid that he believes he can have forgotten none of its incidents. He will assuredly find, if his experience at all resembles my own, that he and his friend have retained very different versions of the same occurrence, that in each case persons who had played an important part in it had wholly dropped from the memory, and that the conversation will have recalled many facts to both the speakers, that had almost passed into oblivion. We recollect the memories of incidents, or the memories of those memories, rather than the incidents themselves; and the original impression, like the original anecdote in the well-known game of "Russian scandal," receives successive modifications at each step until it is strangely condensed and transformed.

I divided such part of the 279 different ideas as admitted of it into groups, according to the period of my life when the association that linked the idea to the word was first formed, and found that almost exactly the half of those that recurred either twice, thrice, or four times, dated back to the period when I had not yet left college, at the age of twenty-two. Of those that did not recur in any of the trials the proportion that dated previously to the age of twenty-two to those of later date was a little smaller, viz., as three to four. All this points to the importance of an early education that shall store the mind with varied imagery, and may form just one half the basis of the thoughts in after-life.

The 279 different ideas fell into three groups. Those in the first and most numerous were characterized by a vague sense of acting a part. They might be compared to theatrical representations in which the actors were parts of myself, and of which I also was a spectator. Thus the word "a blow" brought up the image of a mental puppet, a part of my own self, who delivered a blow, and the image of another who received one; this was accompanied by an animus on my part to strike, and of a nascent muscular sense of giving a blow. I do not say that these images and sensations were vivid or defined—on the contrary, they were very faint and imperfect; indeed, the imperfection of mental images is almost necessary to mobility of thought, because the portions of them that are not in mental view or even in mental focus at the same instant admit of being changed to new shapes, and so the mental imagery shifts with less abruptness than it would otherwise do. The effect partakes more of the character of the changes in a diorama and less of that of a sudden transformation scene. I am not aware that this very common sort of ideas has ever been christened or even so clearly recognized before as I think it deserves to be; therefore I will

call it "histrionic." I find it to be a most important agent in creating generalizations.

The second group of ideas consists of mere sense imagery, unaccompanied by any obscure feeling of muscular tension or action; such as mental landscapes, sounds, tastes, etc. I showed, in a paper read before the Anthropological Society last year,[1] how generalized images admitted of being produced. I took a number of portraits of different persons, who were all represented in the same attitudes and of the same size, and I threw photographic images of these, one on the top of the other, by a contrivance there described, on the same sensitized photographic plates. The result was a picture compounded of that of all the different persons; and so much more numerous are the points of resemblance than those of dissimilarity in different human faces, that the composite picture looked as though it had been taken from a real living individual a little out of focus, and who had somewhat moved during the process. I then pointed out that "a composite portrait represents the picture that would rise before the mind's eye of a man who had the gift of pictorial imagination in the highest degree." It is clear, from the evidence of these composites, that generalized images are no chimeras.

So much for the second group of ideas. The third and last group consisted of purely verbal associations, whether the mere names of persons or things, or bits of quotations in prose or verse.

The seventy-five words were similarly divisible into three groups. The first included such words as "abasement," "abhorrence, "adoration," and "acclamation," all of which could be perfectly expressed in pantomime, and generally gave rise to histrionic ideas. The second group comprised "abbey," "aborigines," "abyss," and the like, all of which admitted of sense representation, either by a visual image, or, in the case of such a word as "acid," by some other sense. In the third group were the words "afternoon," "ability," "absence," "actuality," and others of a like abstract character, difficult to apprehend and realize, and tending to give rise to purely verbal associations. But as two ideas were registered on each occasion, the eight results were usually dispersed among all the groups, though in unequal proportions.

Experiments such as these allow an unexpected amount of illumination to enter into the deepest recesses of the character, which are opened and bared by them like the anatomy of an animal under the scalpel of a dissector in broad daylight. If we had records of the self-examination of many persons, and compared them, I think we should be much impressed by the differences between one mind and another, in the quality, wealth, and appropriateness of their associated ideas, and we should wonder that mutual misunderstandings were not more frequent even than they are.

[1] "Journal of the Anthropological Institute," viii., p. 134; or "Nature," May 23, 1878, p. 97.

I found the purely verbal associations to contrast forcibly in their rapid, mechanical precision with the tardy and imperfect elaboration of highly generalized ideas; the former depending on an elementary action of the brain, the latter upon an exceedingly complicated one. It was easy to infer from this the near alliance between smartness and shallowness.

It so happens that my mental imagery concerns itself more with aspects of scenery than with the faces of men, as I have rather a good memory for localities, and much pleasure in thinking about them, while I am distressed by natural inaptitude for recollecting features. I was therefore surprised to find that the names of persons were just twice as frequent in my associations as those of things, including places, books, and pictures. The associated words that formed parts of sentences or quotations were twenty-seven in number, and tended strongly to recurrence. The majority were of good verse or prose; the minority were doggerel. I may as well specify their origin. Four of the verse quotations were from Tennyson, two from Shakespeare, and eight from other sources partly doggerel. Of the prose, five were from the Bible, and seven from other sources, partly grotesque, and some of them family phrases. I suspect there is a great deal of rubbish in the furniture of all our brains.

The occasional vividness of an idea is very startling, and I do not see my way to explaining it fully; but sometimes I am sure it is due to the concurrence of many associations, severally of small intensity, but in the aggregate very effective. An instance of this is the powerful effect produced by multitudes subject to a common feeling of enthusiasm, religious fervor, or pure panic. On the few occasions on which I have had the opportunity of experiencing such manifestations, it seemed to me that every one of the multitudinous sounds and movements that reached the ear and eye, being inspired by a common feeling, added its effect to that of all the others. When we are in the presence of a single person or of a small company, the empty background fills a large part of the field of view, and dilutes the visual effect of their enthusiasm. Nay, the larger part of the forms of the persons themselves are similarly inexpressive, unless they be consummate actors. But nothing is seen in an enthusiastic multitude but excited faces and gestures, nothing is heard but excited voices and rustlings. Their variety is such that every chord in the heart of a bystander, that admits of vibrating in sympathy with the common feeling, must be stimulated to do so by some of them.

The background of our mental imagery is neither uniform nor constant in its character. It changes in color, tint, and pattern, though, in my case, all these are usually very faintly marked, and it requires much attention to study them properly. Its peculiarities have nothing to do with associated ideas; they appear to depend solely upon chance physiological causes, to which some of our ideas are also undoubtedly due.

The usual faintness of highly generalized ideas is forcibly brought home to us by the sudden increase of vividness that our conception of a substantive is sure to receive when an adjective is joined to it that limits the generalization. Thus it is very difficult to form a mental conception corresponding to the word "afternoon"; but if we hear the words "a wet afternoon," a mental picture arises at once that has a fair amount of definition. If, however, we take a step further and expand the phrase to "a wet afternoon in a country house," the mind becomes crowded with imagery.

The more we exercise our reason, the more we are obliged to deal with the higher order of generalizations and the less with visual imagery; consequently our power of seeing the latter becomes blunted by disuse. Probably, also, the mind becomes less able to picture things to itself as we advance in age. I am sure there is wide difference between my mental imagery now and what it was when I was a child. It was then as vivid and as gorgeous as in a dream.

It is a perfect marvel to me, when watching the working of my mind, to find how faintly I realize the meaning of the words I hear or read, utter or write. If our brain-work had been limited to that part of it which lies well within our consciousness, I do not see how our intellectual performances would rise much above the level of those of idiots. For instance, I just now opened a railway prospectus, and the following words caught my eye, the purport of which was taken in block, "An agreement will be submitted for the consideration and approval of the proprietors on Friday next"; yet I am certain that I had not, and I doubt if I could easily obtain, a good general idea corresponding to any one of the six principal words in the passage, "agreement," "submitted," "consideration," "approval," "proprietors," and "Friday." If I puzzle over the words in detail until I fully realize their meaning, I lose more than I gain; there is time for the previous words to slip out of mind, and so I fail to grasp the sentence as a whole.

The more I have examined the workings of my own mind, whether in the walk along Pall Mall, or in the seventy-five words, or in any other of the numerous ways I have attempted but do not here describe, the less respect I feel for the part played by consciousness. I begin with others to doubt its use altogether as a healthful supervisor, and to think that my best brain-work is wholly independent of it. The unconscious operations of the mind frequently far transcend the conscious ones in intellectual importance. Sudden inspirations and those flashings out of results which cost a great deal of conscious effort to ordinary people, but are the natural outcome of what is known as genius, are undoubted products of unconscious cerebration. Conscious actions are motived, and motives can make themselves attended to, whether consciousness be present or not. Consciousness seems to do little more than attest the fact that the various organs of the brain do

not work with perfect ease or coöperation. Its position appears to be that of a helpless spectator of but a minute fraction of a huge amount of automatic brain-work. The unconscious operations of the mind may be likened to the innumerable waves that travel by night, unseen and in silence, over the broad expanse of an ocean. Consciousness may bear some analogy to the sheen and roar of the breakers, where a single line of the waves is lashed into foam on the shores that obstruct their course.—*Nineteenth Century.*

HEALTH AND RECREATION.

By Dr. BENJAMIN W. RICHARDSON, F. R. S.

THAT all work and no play makes Jack a dull boy is one of those common sayings which we seem bound to accept, whether we like it or not. It is a truthful saying and an untruthful, a wise saying and an unwise, according as one word in it is interpreted, and that word is *play*. If play really means *play* in the strict sense of the term, as it is defined for us in the dictionaries, viz., "as any exercise or series of exercises intended for pleasure, amusement, or diversion, like blindman's-buff"; or as "sport, gambols, jest, not in earnest"—then truly all work and no play makes Jack a dull boy, and Jill a dull girl.

But in these days there is a difficulty in accepting the saying as true, because the idea of play, especially when it is expressed by the term "recreation," is not always represented in the definition I have given above. We now often really transform play into work; and our minds are so constituted that what is one person's work is another person's play. What a backwoodsman would call his horse-like labor, a foremost statesman may call his light of pleasure. How shall we define it? What is play or recreation?

Men differ, I think, on the definition of work and play more than on almost any other subject: differ in practice as much as in theory in regard to it. I have had the acquaintance, and I may say the friendship, of a man who lives, it is said, for nothing but recreation, or pleasure, or play. Such a man will rise at ten in the morning, and after a leisurely, gossiping, paper-reading, luxurious breakfast will stroll to the stables to look after the horses, of each one of which he is very fond. He delights in horses. Thence he will away to the club, will gossip there, read the reviews or the latest new novels, and regale at luncheon. After luncheon he will play a rubber, winning or losing several shillings—it may be pounds. He may then take a ride, or drive, or walk in the park, and have a chat there; or canter over to Kew and look round the gardens, or attend a drum, or visit the Zo-

ological or Botanical Gardens. After this he will return home, and, ably and artistically assisted, will dress for dinner. The dinner, in accordance with his life, will be elegant, sumptuous, entertaining, whether he take it at his own table or abroad. After dinner he may probably go to a ball and dance until two or three in the morning; or, if there be no ball on hand, he may have another rubber, or a round at billiards, or a turn at the play, the opera, or the concert-room, with a final friendly chat and smoke before retiring for rest.

To this gentleman—and I am penciling a true and honest gentleman, not a modern rake of any school of rakes—this mode of life is a persistent pleasure, and to many more it would, I doubt not, be a perpetual holiday. To me it would be something worse than death. The monotony of it would be a positive misery, and I am conscious that many would be found to share with me in the same dislike.

Some will say that is all true enough with respect to persons who have passed out of youth into manhood, but that when life is young the distinctive appreciations for different modes of recreative pleasures are not so well marked out. I doubt, for my own part, this belief. It seems to me that in childhood the tastes for recreative enjoyment are as varied as they are in later years, with this difference, that they are not so effectively expressed. The little mind is ever in fear of the greater, and is often forced to express a gladness or pleasure which it does not truly feel. When children, left to themselves, are independently observed, nothing can be more striking to the observer than the difference of taste that is expressed in respect to the games at which they shall play. More than half the noise and quarrel of the nursery is, in fact, made up of this difference of feeling as to the character of the game that shall be constituted a pastime. In the end, on the rule, I suppose, of the survival of the fittest, the strongest children have their way, and one or two little tyrants drag the rest into their own delights.

I should, on the grounds here stated, venture, then, to say that there is, in point of fact, no more actual difference between work and recreation than what exists as a mere matter of sentiment: that recreation is a question of sentiment altogether, both in the young and the old.

If we could get this fact into our minds in our educational schemes for the young, we should accomplish at once a positive revolution in the training of the young, which revolution would, I think, be attended by the happiest change and train of thought in those who, in the future, shall pass through the first stages of life to adolescence and maturity. The search for amusements, and for new amusements, among the well-to-do would not be needed, since the mind from the first would be naturally brought to find a new delight in each act new called labor. The word "labor," in short, might drop altogether; the praise of labor, which is so often extolled, would find its true meaning; and the blame

of play, which is so often unduly criticised, would have its proper recognition.

It has always seemed to me that in that once high though brief development of human existence; in that period, if we can believe that the art of the period came from the life of it, when the human form took its most magnificent model for the artist still to copy; in that period when the perfection of bodily feature and build indicated, of itself, how splendid must have been the health of the living organizations that stood forth to be copied and recopied for ever—it has always seemed to me, I repeat, that in that wonderful period of Greek history, so effulgent and so short, the reason why such physical excellence was attained rested on the circumstance that among the favored cultivated few, for they were few, after all, there was from the beginning to the end of life no such thing as work and play. Everything was existence—nothing less and nothing more. Every office, every duty, every act must have been an existence for the moment, varied but never divisible into one of two conditions, practical pain or practical pleasure. Life was an enjoyment which nothing sullied except death, and which was purified even from death by the quick-consuming fire, that the life might begin again instantaneously and incorruptibly.

If by some grand transformation we could in our day approach to this conception which has been rendered to us by the history of art, and could act upon it, we should, in a generation or two, attain a degree of health which no sanitary provision, in the common meaning of that term, can ever supply. If we could turn our houses into models of sanitary perfection; if we could release our toiling millions from half their daily labor; if we could tell want to depart altogether; if we could give means of education to every living human being—we should not remove care, and therefore we should not secure health, unless with it all we could also remove the idea of the distinction of labor and pleasure, the morbid notion that some must work and some must play, that the world may make its round.

In this country, so differently placed to the country of the great and the ancient nation of which I have spoken, it is impossible, perhaps, ever to introduce a joyousness like to that which the favored old civilization enjoyed. Our climate is of itself a sufficient obstacle to such a realization. Where the physical conditions of life are so unequal, where we waste in structure of body, whether we will it or not, at certain fixed seasons, and gain, whether we will it or not, at other fixed seasons, it is impossible to attain such excellence by any diversion of mind or variation of pursuit. For universal gladness the sun must play his part, doing his spiriting gently, but never actually hiding the brightness of his face. From us, for long intervals, his face is hidden. Under these variations of the external light and scenery around us we have to cripple our minds through our bodies. Our clothing must be heavy during long stages of the year, and our food so comparatively

heavy and gross that half the power, which might otherwise go off in vivacity or nerve or spirit, is expended in the physico-chemical labor that is demanded for keeping the body warm and moving and living.

To these drawbacks is added the unequal struggle for existence, the partitioning off of our people into great classes, the millions of whom are obliged to work from morning to night, compared with the thousands who are at liberty to make some change in their course of life ; the millions of adults who may be said to be tied to some continuous, monotonous round of labor, until the whole body lends itself to the task with an automatic regularity which the mind follows in unhappy and fretful train, with little hope for any future whatever on earth that shall bring relief.

From whatever side we look upon this picture it seems at first sight to present an almost insoluble problem, when the conception of mixing recreation with work, so as to make all work recreative, is considered. Among the masses there is no true recreation whatever, no real variation from the daily unceasing and all but hopeless toil ; nay, when we ascend from the industrial and purely muscular workers to the majority who live by work, we find little that is more hopeful. There is no true recreation among any class except one, and that a limited and happy few, who find in mental labor of a varied and congenial kind the diversity of work which constitutes the truly re-creative and re-created life.

We get, in fact, a little light on the nature of healthful recreation as we let our minds rest on this one and almost exceptional class of men of varied life and action of a mental kind. They come before us showing what recreation can effect through the mere act of varying the labor. The brain-worker who is divested of worry is at once the happiest and the healthiest of mankind—happiest, perchance, because healthiest ; a man constantly re-created, and therefore of longest life.

Dr. Beard, of New York, who has recently computed the facts bearing on this particular point, gives us a reading upon it which is singularly appropriate to the topic now under consideration. He has reckoned up the life-value of five hundred men of greatest mental activity : poets, philosophers, men of science, inventors, politicians, musicians, actors, and orators; and he has found the average duration of their lives to be sixty-four years. He has compared this average with the average duration of the life of the masses, and he has found in all classes, the members of which have survived to twenty years of age, the duration to be fifty years. He, therefore, gives to the varied brain-workers a value of life of fourteen years above the average. By a later calculation, relating to a hundred men belonging, we may say, to our own time, he has discovered a still greater value of life in those who practice mental labor, seventy years being the mean value of life in them. Thereupon he has inquired into the cause of these differences, so strange and so startling, and has detected, through this analysis, as I and others have, a combination of saving causes, the one cause most

influencing being the recreative character of the work. His observation is so sound, so eloquent, and above all so practical, that I can feel no necessity for apology in giving it at length. He is comparing, in the passage to be quoted, what he calls the happy brain-worker with the mere muscle-worker, and this is the argument:

> Brain-work is the highest of all antidotes to worry; and the brain-working classes are, therefore, less distressed about many things, less apprehensive of indefinite evil, and less disposed to magnify minute trials, than those who live by the labor of the hands. To the happy brain-worker life is a long vacation; while the muscle-worker often finds no joy in his daily toil, and very little in the intervals. Scientists, physicians, lawyers, clergymen, orators, statesmen, literati, and merchants, when successful, are happy in their work without reference to the reward; and continue to work in their special callings long after the necessity has ceased. Where is the hod-carrier who finds joy in going up and down a ladder; and, from the foundation of the globe until now, how many have been known to persist in ditch-digging, or sewer-laying, or in any mechanical or manual calling whatsoever, after the attainment of independence? Good fortune gives good health. Nearly all the money in the world is in the hands of brain-workers; to many, in moderate amounts, it is essential to life, and in large and comfortable amounts it favors long life. Longevity is the daughter of competency. Of the many elements that make up happiness, mental organization, physical health, fancy, friends, and money—the last is, for the average man, greater than any other, except the first. Loss of money costs more lives than the loss of friends, for it is easier to find a friend than a fortune.

The contrast put before us in these forcible remarks is most striking. It is the key to the position in trying to unlock the secret as to what true recreation should be. These brain-workers of whom Dr. Beard speaks are, indeed, the modern Greeks, not perhaps in perfection but in approximation. The Greeks might, possibly, have gone higher than they did in the way of developed physical beauty and of mental endowment, and these happy brain-workers of later ages might, perhaps, more nearly approach the happy Greeks. But both were on the lines toward the highest that may be attainable, and this, as a means of indicating the right line, is my reason for using the illustrations that have been offered.

That which I have so far urged consists, then, of two arguments: Firstly, that recreation to be healthful must, as its meaning conveys, literally, be a process of re-creating; that is, of reconstructing or rebuilding; a practice entirely distinct from what is called play, when by that is meant either cessation from every kind of creation, or enjoyment of abnormal pleasures which weary mind and body. Secondly, that they who are able to live and re-create in the manner suggested are, in positive fact, they who present the healthiest, the happiest, and the longest lives.

From these premises I further draw the conclusion that we have no open course of a reasonable kind before us except to strive to beget a healthful recreation in the direction indicated.

At the same time I do not say this in order to divert attention from what may be rightly called the natural animal instincts of man. I have no doubt there might be a cultivation of mind which should cease to be recreative, and which thereby should be as injurious to the health of the body as an over-cultivation of mere gross mechanical labor, and which might even be more dangerous. It is not a little interesting to observe that the greatest of the Greeks had become conscious of this very danger, as if he had learned its existence from observations in his daily life. Plato, in treating of this subject in one of his admirable discourses, warns us against the delusion that the cultivation of nothing but what is intellectually the best is, of necessity, always the best. It is more just, he says, to take account of good things than of evil. Everything good is beautiful; yet the beautiful is not without measure. An animal destined to be beautiful must possess symmetry. Of symmetries we understand those which are small, but are ignorant of the greatest. And, indeed, no symmetry is of more importance with respect to health and disease, virtue and vice, than that of the soul toward the body. When a weaker and inferior form is the vehicle of a strong and in every way mighty soul, or the contrary; and when these, soul and body, enter into compact union, then the animal is not wholly beautiful, for it is without symmetry. Just as a body which has immoderately long legs, or any other superfluity of parts that hinder its symmetry, becomes base, in the participation of labor suffers many afflictions, and, though suffering an aggregation of accidents, becomes the cause to itself of many ills, so the compound essence—of body and soul—which we call the animal, when the soul is stronger than the body and prevails over it—then the soul, agitating the whole body, charges it with diseases, and by ardent pursuit causes it to waste away. On the contrary, when a body that is large or superior to the soul is joined with a small and weak intellect, the motions of the more powerful, prevailing and enlarging what is their own, but making the reflective part of the soul deaf, indocile, and oblivious, it induces the greatest of all diseases, ignorance. As a practical corollary to these remarks, Plato adds that there is one safety for both the conditions he has specified: neither to move the soul without the body, nor the body without the soul. The mathematician, therefore, or any one else who ardently devotes himself to any intellectual pursuit, should at the same time engage the body in gymnastic exercises; while the man who is careful in forming the body should at the same time unite the motions of the soul, in the exercise of music and philosophy, if he intends to be one who may justly be called beautiful and at the same time "right good."

Such is the Platonic reading of the recreative life as it appeared to him in his day and among his marvelous people. We have but to trouble ourselves with half the problem he refers to, and with but half the advice that he suggests. Little fear, I think, is there among us that the soul should be so much stronger than the body, and so greatly

prevail over it that it should agitate the whole inwardly, and by ardent application to learned pursuits cause the body to waste away. Nor is this to be regretted, because if the danger so stated were a prevailing one we should have two evils to cure in lieu of one which is all-sufficient for the reforming work of many of the coming generations of men.

I have not, I trust, dwelt too long on what I may call the practical definition of recreation as it ought, I think, to be understood, as it once was understood and practiced, and as it is still practiced, if not systematically understood, by a few whose varied and delightful works and tastes make them the healthiest and longest-lived among us.

It is well always to have a standard before us, though it be seemingly unapproachable, and the illustrations I have endeavored to supply of all work and all play, and of long-continued recreation thereupon, form the standard I now wish to set up for observation.

To make all England, and all the world, for the matter of that, a recreation ground; to make all life a grand recreation; to make all life thereby healthier, happier, and longer—this is the question before us.

Confining our observations to our own people and time, it may now be worth a few moments of analytical inquiry as to how far we, in different classes of our English community, are away from so desirable a consummation—the consummation of all human effort toward the perfected human life: the dream of some poets that such a life has been and will return—"Redeunt Saturnia regna"—the dream of many poets that it is to be, if it has not been.

The Registrar-General, with much judgment, due to long and wide experience of the component parts of the nation comprised under the title of England and Wales, has divided the community into six great classes, which classes are, in many respects, so distinct that they may almost be considered as great nations of themselves, having their own individual pursuits, habits, tastes, and, if the word be allowable, recreations. He describes for us—1. A professional class, made up of governing, defending, and learned persons, and numbering some 684,102 persons, chiefly of the male sex; 2. A domestic class, wives and women of the household, and hotel and lodging-house keepers—a large class, the great majority women, numbering as many as 5,905,171—nearly, in fact, six millions; 3. A commercial class of buyers, sellers, lenders, and transporters of goods and produce, chiefly men, and numbering 815,424; 4. An agricultural class, cultivators, growers, and animal-keepers, the majority men, numbering 1,657,138; 5. An industrial class, mechanics, fabric manufacturers, food and drink producers, and purveyors of animal, vegetable, and mineral produce—a very large class, having in it members of both sexes, and numbering 5,137,725; 6. An indefinite, non-productive class; persons of rank and property; and scholars and children; nearly an equality of representation of numbers of both sexes; the whole class including a total of 8,512,706, of whom 7,541,-

508 are scholars and children—the living capital of the next generation of men and of women.

As we glance at these classes we quickly detect that what may be called their vocations are extremely different; that each class—with the exception, perhaps, of two, the professional and the commercial, with that part of the indefinite class which is composed of persons of rank and property, and which approach each other—are as widely separated in tastes and habits and inclinations as they are in labors and works. Looking at the education of body and mind in these classes as a whole, there is certainly little enough of symmetry.

Among the representatives of these classes which are best able to command the advantages of true recreation there is little sound attempt to use the privilege in a refined and reasonable way. The persons who have their time at command, and who belong to the most favored division, are divisible into two groups: a group which does no work at all that can bear the name of useful or applied labor, but which spends all its waking hours at what it considers to be recreative pursuits, which may be laborious, but must not be remunerative; and a group which labors industriously for the sake of return or reward, but which steals from time of labor regular intervals in which to follow out certain of the recreations which form the whole life of the first group, in strict imitation of that envied group, and in hopeless neglect of any recreation of its own better adapted to its real wants and best enjoyments. Each of these groups suffers from the course it follows. The representatives of the first kind lose much, since they are for ever repeating the same to them pleasurable or automatic activity. The second lose, because, while they are ever repeating the same useful activity, they are only relieving that activity by repeating day after day the same automatic and imitative recreations. Thus both are subjected to what may be called the automatism of recreation. The automatism of recreation is bad in every sense, and it is specially bad in the present day, because of the quality of it, as well as the limited quantity. There is no such diversity of recreation as is wanted to keep the body in health by the exercise of the mind. With one man the recreation is all taken out in cards, with another in chess, with a third in billiards, with a fourth in debate or gossip on some one persistent topic of discourse or argument, and so on, for what may be called the in-door recreative life. Nor is it much different with out-door recreative amusement. Some one particular amusement claims the attention of particular men, and to this amusement the men adhere as if they had to live by it, and as if, in fact, there were no other recreative pursuits in the world.

This specialty of recreative pleasure or labor—for soon it becomes labor—leads to consequences which are often of the most serious character. The man who undertakes the recreation at first as an enjoyment, and indeed as a relaxation, is so absorbed in it that he strains every nerve to be eminent in it, a professor of the accomplishment, with

a local repute for his excellence. The moment he enters on this resolve, however, he loses recreation. He sets himself to a new work, be it mental or physical; his mind becomes an emporium for the produce of that one particular culture, and he is in respect to that not far removed from a monomaniac. From the day that he is completely enamored of the special pursuit it is little indeed that he is good for out of it in hours apart from the common vocation of his life. He becomes fretful if for a day he be deprived of his peculiar gratification; irritable if he joins with others in it who are not so skillful as himself; envious if he meets with a rival who is better at it than himself; and often actually sleepless in thinking and brooding over some event or events that have been connected with the previous play or venture.

If the time at my disposal admitted the introduction of detailed illustration of the facts here referred to, I could supply from experience instance upon instance. I have seen an amateur chess-player so infatuated with the game, which he originally sat down to as a relaxation, that he became for months a victim of insomnia. He carried the whole chess-board, set out in various difficult problems, in his brain, if I may use such a simile, studied moves on going to sleep, dreamed of them, woke with the solution solved, was sick and feeble and irritable all next day, followed his usual occupation with languid ability and interest, resumed his play at night with excited but not recruited determination, got more and more sleepless, and at last failed to sleep altogether. I have known more than one similar illustration in whist-players and in great billiard-players, and have seen the results of these so-called recreations end in the most sad physical disaster, when the pursuit of them has been made a matter of living importance, and when the player has ever had in his mind that pitiful *if:* "If I had done this or that—if I had made that move on the board—if I had played that card—if I had made that stroke, how would the case have been?" It matters little what the answer to the question may be—whether it be that by such a move, card, or stroke, the game would have been lost or won; the perplexing doubt is there to annoy, and it keeps up an irritation which imperceptibly wears out the animal powers and does permanent injury to life. You see men while still they are actually young grow rapidly like old men under this supposed recreative strain. They grow prematurely careworn, prematurely gray, prematurely fixed in idea and obstinate in idea, angry at trifles, baffled by trifles, and, in a word, young senilities.

In this busy city, in the great places of business near to which we now are, there are hundreds—may I not extend the calculation and say thousands?—of men who, in pursuit of the recreative pleasures I have specified, or of others similar in their results, are wearing themselves out twice as fast—and more than twice—as they are by the legitimate labor to which they have to apply themselves that they may earn their daily bread. It is the fact; and the observant physician, as he listens

to the suffering statements of these men, is obliged in his own mind to differentiate between the assigned and what is often the real cause of that train of evils to which it is his duty to lend an attentive ear.

Thus, among the most intelligent part of the community—among the part that can help itself—there is no systematized scale or class of recreations that can be relied upon to afford the change really demanded for health. Nor are matters much improved when we take up the kind of change that is sought after by the same classes in the matter of physical recreation. When the Volunteer movement first came under notice, and for some time after it first came into practice, it was the hope of all sanitary men—I believe without any exception—that the exercise, and drill, and training, and excitement which would be produced by the movement would prove most beneficial to the health of the male part of the people at a period of life when the training of the physical powers is most required and often most neglected. I remember being quite enthusiastic at that change and its promises, and I recalled the other day an often-quoted paper or essay which had sprung out of that enthusiasm, and which I dare say at the time it was written seemed common sense itself. I can but feel now that the hope was begotten of inexperience. The movement has been a success, I presume, in a national and political point of view, but a careful observation of it from its first until this time has failed to indicate to me, as a physician, that it has led to any decided improvement in the health generally of those who have been most concerned in carrying it out by becoming its representatives. Certain it is that nothing affirmative of good stands forth in its favor, and I wish I could stop with that one neutral statement. I can not in order of truth and fairness so stop, for I have seen much injury from the process. To say nothing of the expense to which it subjects many struggling men, to the loss of time it inflicts on them, to the neglect it inflicts at the fireside and home, to the spirit of contest of mind and fever of mind which it engenders; to say nothing, I repeat, of these things—all of which, nevertheless, are detrimental, indirectly, to the health of the men themselves and of those who surround them in family union—there is a direct harm often inflicted by the service, call it recreation if you like, which is not to its credit. The man who has advanced just far enough in life to have completed his development of growth, and to have lost the elasticity of youth, the man who has rather too early in life become fat and, as he or his friends say, puffy, the man who has, from long confinement in the office or study, found himself dejected and dyspeptic, each one of these men has passed into the ranks of the Volunteers, in order to regain the elastic tread, to throw off the burden of fat, or to find relief from the dyspeptic despondency. For my part, I have never been able to discover a good practical result in any of these trials; but I have seen many bad practical results. I have seen the partly disabled men, in the conditions specified, striving to do their best to keep alive and

be on a level with younger and athletic men, and I have been obliged to hear of the signal and natural failure of the effort. I have heard of the attempts to meet the failure by the tempting offer and too willing acceptance of what are called artificial stimulants to give temporary support, and I have been obliged to discover in persons so overtaxed and so over-stimulated a certain heavy excessive draw on the bank of life, an anticipation of income which, in the vital as surely as in the commercial world, is the road to a premature failure and closure of the whole concern.

There are many who will agree with me, I doubt not, on this point; there are many men, and there are more women—for wives and mothers are far more observant and wise than husbands and fathers on these points—who will be able to bring their experience to bear in confirmation of that which I have spoken; and these will agree that to put men of different ages and of different states of constitution and habits in the same position for recreation; to trot them all through the same paces; to make them all wear the same dress, walk or march the same speed, carry the same load, labor the same time, move the limbs at the same rate; that to construct one great living machine out of a number of such differently built machines is of necessity an unnatural and, in the end, a ruinous process. There are some, however, who, while admitting so much, will put in a plea for the younger members of the community. They will insist that the younger men, the men who are from nineteen or twenty up to twenty-nine or thirty, may with advantage go through the recreation of training after the Volunteer fashion. The case is much stronger on behalf of this argument, but even in the respect named there requires a great deal of discrimination. A race of strong men may be bred, and a weak race may, by gradual development, be raised into a strong; but a weak man, born weak, can, through himself, be led a very little way into strength; while during the process of training he can most easily be broken into utter feebleness, so that the last of the man may be worse than the first. Hence, in training the weak into strong through any form of recreation, mental or physical, but specially physical, there must be a singular discrimination. In this instance of Volunteering as a mode of progress in physical health for the young there are dangers that ought to be avoided with religious care. To advise a weakly youth of consumptive tendency and feeble build, or one having some special proclivity to rheumatic fever, heart-disease, or other well-defined hereditary malady, to compete with other men of the same age and of athletic nature, in the same recreative exercise, is to deceive the youth into danger. To force such a one into violent competitive exercise, and tax him to the same degree of vital withdrawal day after day, or week after week, is to subject him all but certainly to severe, if not fatal, bodily injury.

I have selected the recreative exercise of Volunteering as a case for illustration of an important lesson, and I have made the selection, not

because the recreation is special as a sometimes harmful recreation, but because more persons are concerned in it just now than in aught else of the same kind of recreative pursuit.

There are many other so-called recreations which are even more injurious to the feeble adolescent and to the enfeebled matured individuals, who seek to find symmetry of health in extreme recreation. Football is one of these recreations fraught with danger. Rowing is another exercise of the same class. Polo, while the fever for it lasted, was found to be of similar cast. Excessive running and prolonged and violent walking—in imitation of those poor madmen whose vanity trains them to give up sleep and all the natural ordinances that they may walk so many thousand miles in so many thousand hours—these are alike injurious as physical recreations unless taken with the same discrimination as is required by those who enter into the Volunteer movement.

As we pass from the freer and wealthier classes of the community into the less prosperous we find no marked improvement whatever in any form of recreation. We begin, in fact, to lose sight of the recreation that ministers to either mind or body in a sensible and healthy degree, and to see that which should be recreative replaced almost entirely by continuous and monotonous labor. The idea of symmetry of function and development between mind and body disappears nearly altogether; so that, indeed, to mention such a thing would, in some of the classes concerned, be but to treat on a subject unknown, and therefore, as it would seem to them, absurdly unpractical. To tell a country yokel that his body is not symmetrical in build, and that his mind has no kind of symmetrical relation to his body, were cruel, from its apparent satire. Yet why should it be? Why should ignorance and labor so deform any one that the hope of a complete reformation, the hope of the constitution of a perfect body and in it a perfect mind, should seem absurd? It is not the labor that is at fault. The labor is wholesome, healthful, splendid; it is a labor compatible with the noblest, nay, the most refined of human acquirements. Why should it be incompatible with perfect physical conformation of mind and body? It is not, indeed, the labor that is at fault, but the ignorant system on which it is carried out.

There is much difference, in fact, between the three classes of the community called the domestic, the agricultural, and the industrial, in respect to the work, the recreation, and the resultant health pertaining to each class. The domestic class as a whole is, by comparison with the industrial, fairly favored. The members of it lead, it is true, a monotonous life, and see often but little of the beauties of external nature, but they find in the amusements they provide for those who are about them some intervals of change which are, as far as they go, of service. Moreover, except in that part of the class which is engaged in disposing of spirituous drinks, and which pays a heavy vital taxation from the recreation springing out of that vocation, its representatives are not exposed

to harmful recreations to an extreme degree. The domestic class therefore presents, on the whole, a fairly healthy life. The majority of its members are women and mothers; and, in the gladness with which they tender their love and adoration to the young and innocent life that comes into their charge, they find perchance, after all, the purest pleasure, the most enhancing, the most ennobling recreation, that, even in the midst of many cares and sorrows and bereavements, falls to the lot of any section of the great community.

The agricultural class, less favored in recreative opportunities than the others which have passed before us, living a laborious and very poor life, ever at work for small returns, and finding little recreation beyond that which is of mere animal enjoyment, is still comparatively favored. To the agricultural worker the seasons supply, imperceptibly, some delight that is beneficial to the mind.

> These as they change, Almighty Father! these
> Are but the *varied* God.
> Mysterious round! What skill, what force divine
> Deep felt in these appear: a simple strain,
> Yet so delightful, mixed with such kind art,
> Such beauty and beneficence combined,
> And all so forming one harmonious whole—
> Shade unperceived, so soft'ning into shade
> That as they still succeed they ravish still.

The labor of the out-door agricultural class, blessed by these changing scenes which the exquisite poet above quoted so exquisitely describes, is varied also in itself. Each season brings its new duty: the spring its meadow-laying and sheep-shearing; the summer its haymaking; the autumn its harvesting and harvest-home, and fruit-gathering; the winter its plowing and garnering, and cattle-tending; with sundry well-remembered holidays which are religiously kept. There may be through all this continuous wearing labor; there is; but, as it is not monotonous, it is to some extent recreative, and the facts of mortality tell that it is saving to life. The agricultural classes present a mortality below the average in the proportion of ninety-one to one hundred of the mass of the working community. Moreover, there is hope for the agricultural classes in the fact that it is comparatively an easy task to supply them with a perfect roundelay of beautiful recreations for their resting hours. It is only to remove from them the grand temptations to vice in the beer-shop and the spirit-store, and to substitute for these resorts a rational system of enjoyments, to win for the country swain the first place in that symmetry which Plato called "right good."

The utter blankness, the blankness that may be felt, in respect to recreation is realized most in the millions of the industrial class who live in the everlasting din of the same mechanical life; who see ever before them the same four walls, the same tools, the same tasks; who

hear the same sounds, smell the same odors, touch the same things, feel the same impressions, again and again and again, until the existence is made up of them, never to be varied until death doth them part. It is to this class—repining, naturally envious, naturally restless, and at this moment of time unsettled, mournful, and disaffected, to an extent which few, I fear, of our rulers comprehend—it is to this class most of all that the balm of wholesome recreation is most necessary, and for whom the absence of it is most dangerous. In this class there is no such thing as health. It is a blessing not to be found. You could not, I solemnly believe, bring me one of them that I dare, as a conscientious physician, declare, after searching examination, to be physically healthy in any approach to a degree of standard excellence. As a rule the average of life among those who have passed twenty-five would not be above fifteen years.

In these classes we see the effect of what I may venture to call the denseness of work, leading to mortality in the most perfect and distinctive form—work without any true recreative relief; work without anything changing or becoming recreative in itself; work relieved at no regular intervals for introduction of new life.

The greatest of all the *social* problems of our day is involved in this study of the manners and modes of thought of over five millions of adult English people, all confined in order that they may labor, with no satisfactory relief from labor, and with no land of promise before them. The greatest of all the *political* questions of our day is also involved in this same study. The physician knows that the wisest of mankind, the most intelligent of mankind, are only half their former selves when they are out of health. He knows that health which is bad, but not sufficiently bad to prostrate the physical powers to such an extent as to cause inactivity of the will, is the most perplexing of all states of mind and action with which he has to deal. He feels thereupon a fellow-sympathy with the political physician who is called upon to treat the industrial masses in mass; to provide for their minds' health, to calm their excitement, to plant confidence in their hearts, and, most arduous task of all, to find out the way for securing for them those two grand remedies in the Pharmacopœia of the ordinary physician, rest and change of scene, in pure and open air.

"They find their own recreations, these working millions," I think I hear some one say. They *try* to find them, would be the truer statement. They try their best, but they have found few conducive to health, many that are fatal. They are to be pitied and pardoned for these errors of their finding. What if they do discover recreation of the worst kind in the bar and saloon of the spirit-seller? Have they not the example of the wealthier classes before them, teaching that the same indulgence, in another style, is recreation? May they not ask how many other obtainable pleasures are provided for them, and whether many, too many, of obtainable pleasures so called, and so bad,

are not positively thrust upon them? They have labored all day in monotony: where shall they go for recreation, and what shall the recreation be? If they go far away they are removed from the sphere of their labors; if they look near to their own abodes, they find not one true and ennobling pastime, but fifty that are degrading, and, at the same time, filled with every possible temptation.

I apply this to our own people; but it is, I fear, equally applicable to other peoples. Dr. Beard, the American I have already quoted, writes his experience, gathered in his own country, as follows: "To live," he says, speaking of the same classes, "to live on the slippery path that lies between extreme poverty on the one side and the gulf of starvation on the other; to take continual thought of to-morrow, without any good result of such thought; to feel each anxious hour that the dreary treadmill by which we secure the means of sustenance for a hungry household may, without warning, be closed by any number of forces, over which one has no control; to double and triple all the horrors of want and pain by anticipation and rumination—such is the life of the muscle-working classes of modern civilized society; and when we add to this the cankering annoyance that arises from the envying of the fortunate brain-worker, who lives at ease before his eyes, we marvel not that he dies young, but rather that he lives at all."

There remains still in the list of classes requiring recreation, and the health that springs from it, the last or indefinite class. Of the purely indefinite of these I need not speak; for they, the waifs and strays of our civilization, are, I fear, under little influence of such refining agencies as we would put forward for the future. With the very small class of persons of rank and property, less than 169,000 altogether, I have dealt already, by joining them with the professional and commercial well-to-do classes. To the seven and a half millions of scholars and children and their recreations attention will be called in a new chapter.—*Gentleman's Magazine.*

EARLY TRACES OF MAN.[1]

By G. DE MORTILLET.

QUATERNARY MAN.—The man of geological time—fossil man—is now a fact so clearly demonstrated that it is no longer called in question. The recent exposition of anthropological sciences showed us his works plentifully scattered throughout France, England, Spain, and Italy.

But, though the existence of quaternary man in the southwest of Europe is no longer denied, there is a school which, walking with fear

[1] Translated by J. Fitzgerald, A. M., from the "Revue d'Anthropologie."

and hesitation in the path of progress, has its mind made up to contest his existence in the Orient. What the leaders of this school maintain is this: In the East, say they, civilization, and consequently historic records, date back to a very remote time. Is it not, then, possible that geological time still persisted in Europe, and especially in western Europe, while in Egypt the historic dynasties were being founded?

To put forth such a proposition as this, one must be ignorant of the data of geology. The remarkable collections exhibited at the Anthropological Exposition have shown that man was contemporary not only with the reindeer, the saiga, the chamois, and the marmot on our plains; not only with the mammoth, and the *Rhinoceros tichorhinus*—that is, with the fauna of the glacial period—but also with the great hippopotamus, the *Elephas primigenius*, and the rhinoceros of Merk. All geologists are agreed that the duration of the period in which we live is as nothing compared with that of the Quaternary period. It is as a day compared to ages, as a drop of water in a stream. All paleontologists understand what a length of time is requisite for the rise and decline of animal species—species which, while they have been upon the earth, have been lavishly distributed over an enormous area.

But we have no need of the general data of geology and paleontology in order to meet the objection. The Exposition of the Anthropological Sciences furnished materials which reduce it to a nullity. There were exhibited perfectly characterized quaternary instruments of silex from the East—from the most ancient seats of civilization, Egypt and Syria. In those countries then, no less than in France and England, quaternary man preceded all the historic civilizations.

The earliest Quaternary epoch, the preglacial, is characterized, so far as man's works are concerned, by a stone implement of peculiar form. It is dressed on its two sides, usually rather roughly chipped; it is rounded at the base, pointed at the top, and its edges are pretty sharp. In general form it is more or less almond-shaped. This implement, in past times called by workmen in quarries "langue de chat" (cat's tongue), is now called "hache de St. Acheul," or "hache acheulienne" (hatchet of St. Acheul), terms derived from the locality in which it has been oftenest found. They have been found in abundance in the quaternary alluviums of France, England, and Spain. Nay, within a few years they have been found in the valley of the Delaware near Trenton, New Jersey, by Dr. Charles C. Abbott. The figures which he has published, and his descriptions, tally exactly with the St. Acheul hatchets of France and England.

Nor is it in the New World only that the existence of man in the earliest portion of the Quaternary period has been proved; the same thing is true of the Old World. M. Place, the explorer of Assyria, has brought to light a St. Acheul hatchet of silex which he found under the ruins of the palace of Khorsabad. At the exposition, the Abbé Richard showed a St. Acheul hatchet, also of silex, from the lake of Tiberias.

A still more conclusive proof is furnished by Professor Henry W. Haynes, of Boston, who reports a number of wrought flints from Egypt, among them several clearly characterized St. Acheul hatchets.

In the February number (1869) of the "Matériaux pour l'Histoire de l'Homme," M. Adrien Arcelin first made the announcement that the grand Egyptian civilization, like all other civilizations, was preceded by an age of stone. He had just collected in Upper Egypt several chipped flints. Toward the close of the same year this discovery was confirmed by Messrs. Lenormant and Hamy. All the specimens brought home by these earliest explorers might be regarded as belonging to the Robenhausen epoch, or age of polished stone—only one specimen, presented to the museum of St. Germain, came anywhere near the St. Acheul type.

After Arcelin's discovery, collections of dressed flints were multiplied in Egypt, though without throwing much light upon the question. But Sir John Lubbock, in an essay illustrated with fine plates, gave figures of three flint implements found at Luxor and at Abydos, which are undoubtedly St. Acheul hatchets.

Among the wrought flints brought from Egypt and exhibited by Mr. Haynes are several which incontestably are of the quaternary type. Among them we see scrapers and arrow-heads, the latter belonging to a type which in France occurs only in glacial formations. The collection also embraces more ancient forms, preglacial forms, referable to the early portion of the Quaternary period, viz., St. Acheul hatchets of flint.

These St. Acheul hatchets come from two very distinct localities: one lot is from the neighborhood of Luxor, in Upper Egypt, the other from the environs of Cairo, in Lower Egypt. The flint used, as is clearly proved by Delanoue, comes from the nummulitic formations. These formations are found *in situ* in Upper Egypt; and the St. Acheul hatchets of that region are as a rule heavier and better wrought, above all, more completely wrought. In the environs of Cairo there are no rocks *in situ*; and, as for flint, only rounded nodules are found. These nodules have been wrought into the forms of implements. This is easily seen, for all the St. Acheul hatchets of that locality still bear at their base traces of the original rounded surface of the nodules.

From these archæological data, i. e., from the nature and the form of the objects, we may conclude that the man of the earliest Quaternary times lived in Egypt simultaneously with his existence in Europe, and that in both of these regions his industrial development was about the same, extremely primitive.

And geological observation confirms these deductions. It was not on the surface of plateaus that Mr. Haynes found these St. Acheul implements. On the contrary, most of them, at least those from the neighborhood of Luxor (forming the greater number), were found in the bottom of the ravines of Bab-el-Moluk. These ravines are cut deep

into the quaternary deposits by the torrents which, in seasons of heavy rainfall, carry to the Nile the waters from the mountains of Libya.

Thus, then, thanks to the Exposition of the Anthropological Sciences, we are in a position to show that the oldest Egyptian civilization —that of the earliest dynasties—which dates back 4,000 years before our era, was preceded by an age of polished stone, and that before that period Egypt, like all the rest of the world, was occupied by quaternary man.

Tertiary Man.—Important as are the results of the Anthropological Exposition from the point of view of quaternary man, they are still more so from the point of view of tertiary man.

But first let us understand what is meant by the terms quaternary man and tertiary man.

The fauna of the mammals serves clearly to determine the limits of these later geological periods.

The Tertiary is characterized by terrestrial mammals entirely different from extant species; the Quaternary by the mingling of extant with extinct species; the present period by the extant fauna.

The man of the early Quaternary, he who made the St. Acheul hatchets and used them, is the man of Neanderthal, of Canstatt, of Enggisheim, of La Naulette, of Denise. He is indubitably a man, but differing more widely from the Australian and the Hottentot than the Australian and Hottentot differ from the European. Hence unquestionably he formed another human species, the word species being taken in the sense given to it by naturalists who do not accept the transformation doctrine.

Tertiary man, therefore, must have been still more distinct—of a species still less like the present human species—indeed, so different as to entitle it to be regarded as of distinct genus. For this reason I have given to this being the name of man's precursor. Or he might be called anthropopithecus—the man-monkey.

The question of tertiary man should therefore be expressed thus: Did there exist in the Tertiary age beings sufficiently intelligent to perform a part of the acts which are characteristic of man?

So stated, the question is settled most completely by the various series of objects sent to the Anthropological Exposition.

The first and oldest of these collections was that made by the late Abbé Bourgeois, at Thenay (Loir-et-Cher). At the International Congress of Prehistoric Archæology and Anthropology, held in Paris in 1867, the Abbé Bourgeois exhibited tertiary flints which, he claimed, had been chipped intentionally. These early specimens were not very conclusive, lost as they were amid a multitude of other specimens which certainly had not been fashioned intentionally, unless one can suppose that they had been intentionally split by the action of fire. The result was, that the abbé's communication won to his side but few adherents.

But, profoundly convinced of the reality of his discovery, the Abbé Bourgeois did not lose heart on suffering this partial repulse. He continued his researches with vigor, and again, in 1872, provided now with better specimens, he raised the question at the Brussels Congress. There he made some headway among the best experts. But on the commission which was specially appointed to examine the flints were several members who knew but very little directly about the manner of working on flint, and they either hesitated or passed an adverse judgment. Hence the question was not definitively settled. This result, half success, half failure, stimulated the ardor of the accomplished naturalist; he continued his investigations, and so succeeded in collecting for the Anthropological Exposition a remarkable series of flint implements which dispels all doubt.

This collection was made up of flints which beyond a doubt had undergone the action of fire. They are full of cracks, and even quite discolored. With these are other flints, far more numerous, which have simply been split by fire. Among them are some which unquestionably have been neatly and regularly retouched on one or both of their margins. Every one who has carefully and impartially examined them has admitted that the second dressing (*les retailles*) was certainly intentional, and consequently that it was the work of an intelligent creature.

It remains to determine the age to which these flints belong. They were collected at Thenay, in formations clearly *in situ* and intact, and belonging to the formation known among geologists as "calcaires de Beauce"; but now these calcaires de Beauce constitute the lower strata of the Middle Tertiary. This is shown by the fauna which the Abbé Bourgeois exhibited in connection with the flints. This fauna, which comes from the sands of the Orléanais, which directly overlie the calcaires de Beauce, comprises great mastodons and dinotheriums belonging to the Lower Miocene. Then there is the acerotherium, a genus akin to the rhinoceros, and which was found in the very same stratum as the fire-split and redressed flints.

It results, therefore, from the Abbé Bourgeois's researches, that during the Middle Tertiary there existed a creature, precursor of man, an anthropopithecus, which was acquainted with fire and could make use of it for splitting flints. It also knew how to trim the flint-flakes thus produced and to convert them into tools.

This curious and interesting discovery for a long time stood alone, and arguments were even drawn from this isolatedness to favor its rejection. Fortunately, another French observer, M. J. B. Rames, has found in the vicinity of Aurillac (Cantal) in the strata of the upper part of the Middle Tertiary—here, too, in company with mastodons and dinotheriums, though of more recent species than those of Thenay—flints which also have been redressed intentionally. Here, however, the flints are no longer split by fire, but by tapping. It is something more than a continuation, it is a development. Among the few speci-

mens exhibited by M. Rames, whose discoveries are quite recent, is one which, had it been found on the surface of the ground, would never have been called in question.

The weighty facts developed by French investigators received striking confirmation in the Portuguese department of the Exposition. A distinguished *savant* of Lisbon, Senhor Ribeiro, director of the Geological Bureau of Portugal, sent a collection of flints and quartzites found in the strata of the Middle Tertiary or Miocene and in the Upper Tertiary or Pliocene of the valley of the Tagus. Among these specimens—ninety-five in number—are twenty-two which bear unquestionable traces of intentional chipping. Nine specimens, all of flint, are described as coming from the Miocene. Of the others, purporting to be Pliocene, seven are of flint and six of quartzite. All these specimens are roughly chipped, and nearly all are triangular in form, and not redressed, whether the material be flint or quartzite.

Thus, then, the Anthropological Exposition, important though it was from the point of view of quaternary man, is still more important from the point of view of tertiary man—man's precursor. His existence can no more be denied.

WHY DO WE EAT OUR DINNER?

By Professor GRANT ALLEN.

EARLY last year a paragraph went the round of the papers to the effect that a large female anaconda-snake, in the reptile-house at the Zoölogical Gardens, after a fast of a twelvemonth, had at length been induced to kill and swallow a duck. This very touchy and vindictive lady, it appears, had taken such grave offense at her capture in her South American home, and at her subsequent compulsory voyage to Great Britain, that she sulked persistently for a whole year, and invariably refused the keeper's most tempting offers of live rabbits or plump young pigeons. Month after month she lay passive in her cage, with her heart beating, her lungs acting, and all her vital functions proceeding with the usual slow regularity of snake-life ; but not a mouthful of food did she attempt to take, and not a single fresh energy did she recruit from without to keep up the working of her animal mechanism. As I read this curious case of a genuine "fasting girl" in my "Times" one morning, the thought struck me forcibly—"Why, after all, should we expect her to feed? Why should she not go on for ever without tasting a morsel? In short, why should we eat our dinner?" And I set myself to work at once to find out what was the general opinion of the unscientific public upon this important though novel question.

Singularly enough, I found that most people were content to eat their dinner in a very unreasoning and empirical way. They had al-

ways been accustomed to dine daily from their childhood upward, they felt hungry at the habitual dinner-hour, and they sat down to their five courses with an unquestioning acceptance of the necessity for feeding to prevent starvation. But when I inquired *why* people who did not eat should starve, *why* they should not imitate the thrifty anaconda, and take one meal in a twelvemonth instead of three in a day, they appeared to regard my question as rather silly, and as certainly superfluous. Yet I must confess the query seems to me both pertinent and sensible; and it may be worth while to attempt some answer here in such language as can be understanded of the people, without diving into those profound mysteries of formulæ and equations with which physicists love to becloud the subjects of their investigation.

A still more startling case than that of the anaconda will help to throw a little light upon the difficult problem which we have to solve. An Egyptian desert-snail was received at the British Museum on March 25, 1846. The animal was not known to be alive, as it had withdrawn into its shell, and the specimen was accordingly gummed, mouth downward, on to a tablet, duly labeled and dated, and left to its fate. Instead of starving, this contented gasteropod simply went to sleep in a quiet way, and never woke up again for four years. The tablet was then placed in tepid water, and the shell loosened, when the dormant snail suddenly resuscitated himself, began walking about the basin, and finally sat for his portrait, which may be seen of life-size in Mr. Woodward's "Manual of the Mollusca." Now, during those four years the snail had never eaten a mouthful of any food, yet he was quite as well and flourishing at the end of the period as he had been at its beginning.

Hence we are led to the inquiry—What is the actual function which food subserves in the human body? Why is it true that we must eat or we must die, while the snake and the snail can fast for mouths or years together with impunity? How do we differ from these lower animals in such a remarkable degree, when all the operations of our bodies so closely resemble theirs in general principle?

Everybody has heard it said that food is to men and animals what fuel is to a steam-engine. Everybody accepts this statement in a vague sort of way, but until the last few years nobody has been able really to explain what was the common feature of the two cases. For example, most people if asked would answer that the use of food is to warm the body, but this is really quite beside the question: because, in the first place, the use of fuel is not to warm the steam-engine, but to keep up its motion; and, in the second place, many animals are scarcely perceptibly warmer than the medium in which they live. Again, most people show in every-day conversation that they consider the main object of food to be the replacement of the *materials* of the body; whereas we shall see hereafter that its real object is the replacement of the *energies* which have been dissipated in working. Indeed, there is no more reason why the materials of an animal body should waste away

of themselves, apart from work done, than there is for a similar wasting away in the case of a mineral body such as a stone. When an animal does practically no work, as in the instance of our desert-snail, his body actually does not waste, but remains throughout just as big as ever. So we must look a good deal more closely into the problem if we want to understand it, and not rest content with vague generalities about food and fuel. Such half knowledge is really worse than no knowledge at all, because it deludes us into a specious self-deception, and makes us imagine that we comprehend what in fact we have not taken the least trouble to examine for ourselves.

Let us begin, then, by clearly realizing what is the use of fuel to the steam-engine. Obviously, you say, to set up motion. But where does the motion come from? "From the coal," answers the practical man, unhesitatingly. "Well, not exactly," says the physicist, "but from the coal and the air together." All energy or moving power, as we now know, is derived from the union of two bodies which have affinities or attractions for one another. Thus, if I wind up a clock, moved by a weight, I separate the mass of lead in the weight from the earth, for which it has the kind of affinity or attraction known as gravitation. This attraction then draws together the weight and the earth; and, in doing so, the energy I put into it is given out as motion of the clock. Similarly with coal and air: the hydrogen and carbon of the coal have affinities or attractions toward the oxygen of the air, and when I bring them together at a high temperature (of which more hereafter) they rush into one another's embrace to form carbonic acid and water, while their energy is given off as heat or motion of the surrounding bodies. We might have whole minefuls of coal at our disposal; but if we had no oxygen to unite with it, the coal would be of no more use than so much earth or stone. In ordinary life, however, the supply of oxygen is universal and abundant, while the supply of coal is limited; and so, as we have to lay in coals, while we find the oxygen laid in for us, we always quite disregard the latter factor in our fires, and speak as though the fuel were the only important element concerned. Yet one can easily imagine a state of things in which oxygen might be deficient; and in a world so constituted it would have to be regularly laid on in pipes, like gas or water, if the people wished to have any fires.

All energy, then, is derived from the separation of two or more bodies having affinities for one another. So long as the bodies remain separate, the energy is said, in the technical slang of physics, to be *potential;* as soon as the bodies unite, and the energy is manifested as motion, it is said to be *kinetic.* But these words are rather mystifying to ordinary readers, and frighten us by their bigness and their abstract sound; so I shall take the liberty of altering them for our present purpose to *dormant* and *active* respectively, which are terms quite as well adapted to express the meaning intended, and not half so likely to land us in an intellectual *cul-de-sac*, or to envelop us in a logical fog.

When we take a piece of coal and a lot of free oxygen, we possess energy in the dormant state. But though the oxygen has strong attractions for the carbon and hydrogen, they can not unite, because their atoms do not come into close contact with one another, and because the two last-named substances are bound up in the solid form of the coal. We might compare their condition to that of a weight suspended by a string, which has strong attractions toward the earth, but can not unite with it till we cut the string. Just analogous is our action when we apply a match to the coal. The heat first disintegrates or disunites little atoms of the hydrocarbons which make it up, and sets them in a state of rapid vibration among themselves. This vibration brings them into contact with the atoms of oxygen, which at once unite with them, causing a fresh development of heat, and a liberation of all the dormant energy, which immediately assumes the active form. The carbonic acid and water (or steam) thus produced fly up the chimney, carrying with them the little bits of unburned coal which we call smoke; and a current of fresh oxygen rushes in to unite with the fresh atoms of hydrogen and carbon which have been disengaged by the energy liberated from their fellows. So the process continues, till all the coal has been converted into carbonic acid and water—of course by the aid of a corresponding quantity of oxygen—and all the energy has been turned loose as heat upon the room in which we sit and upon the air outside.

In the case of an ordinary fire, where warmth is the single object we have in view, we only think of the heat, and disregard the other aspects of the process. But it is clear that an enormous amount of motion has also been set up by the energy of the free coal and oxygen, as exemplified by the draught up the chimney, and the numerous currents of air produced by its action within and without the room. Now, in a steam-engine we deliberately make use of this motion for our own purposes by a specially devised mechanism. We allow the fire to heat and expand the water in the boiler, thus transferring to its molecules the separation which formerly existed between the atoms of the coal and the oxygen. Then we make the expanded water or steam push up the piston, and we connect the piston in turn with a crank which sets in motion the wheels, and so passes on the active energy to the mill, train, or ship which we desire to move, as the case may be. Thus the dormant energy of the coals and oxygen is liberated in the active state by their union, and is finally employed to effect movement in external bodies by the intermediation of the boiler. Even then the energy does not disappear: for energy, like matter, is indestructible; but it merely passes by friction as heat to that wonderful surrounding medium which we call ether, and is dissipated into the vast void of space, no longer recoverable by us, though quite as really existent as ever.

In what way, however, has all this to do with the reason for eating our dinners? Simply this: Men and other animals may be regarded from the purely physical point of view as a kind of conscious locomo-

tive steam-engine, with whom food stands in the place of fuel, while the possible kinds of movement are infinitely more varied and specialized. I do not mean to advance any of those "automatic" theories which have been so current of late years. Whether they are true or false, they have nothing to do with our present subject. I only want to put in a plain light an accepted scientific truth. Men differ enormously from steam-engines in their possession of consciousness, wills, desires, pleasures, pains, and moral feelings ; but they agree with them in the purely physical mechanism of their motor organs. A man, like a steam-engine, can not move without his appropriate fuel ; and if the fuel is not supplied, the fire goes out and the man dies. The exact manner in which the materials are utilized for keeping up this vital flame is the question to which we must now address ourselves.

Food-stuffs and coal agree essentially in the chief characteristics of their chemical constitution. Both consist mainly of hydrogen and carbon, and both possess energy in virtue of the fact that their affinities for oxygen are not satisfied. Water contains hydrogen, and carbonic acid contains carbon ; but we can get no motion out of these, because in them the oxygen has already united with the atoms for which it had affinity, and the separation necessary for dormant energy has ceased to exist. But in bread, meat, potatoes, or coal, the hydrogen and carbon remain in their free state, ready to unite with oxygen whenever the chance is presented to them. All alike obtained their energy in the same way. The rays of sunlight falling upon the leaves of their original trees or plants separated the oxygen from the water and carbonic acid in the air, and built up the free hydrocarbons in their tissues. The energy which they thus drank in has remained dormant within them ever since: in the case of the bread for a few short months, in that of the coal for countless millions of geological cycles. But, however long it may have rested in that latent form, whenever an opportunity occurs the atoms will reunite with oxygen, and the energy will once more assume the active shape. There is really only one serious difference between coal and food, and that is that most foods contain another element, nitrogen, as well as carbon and hydrogen ; and this nitrogen is an absolute necessity for the animal if it is to continue living. But there are good reasons for suspecting that nitrogen is not itself a fuel, being rather analogous in its nature to a match, and having for its business to set up the first beginnings of a fire, not to keep the fire going when it has once been lighted. So that this apparent difference of kind is really seen to be unimportant when we get to the bottom of the question.

The various matters which an animal eats consist of pure food-stuffs and of useless concomitant bodies: just as coal consists of pure fuel and of the useless mineral matter known as ash. When an animal eats his dinner, the process of digestion and assimilation takes place, and has the ultimate result of separating the pure food-stuffs from the

useless concomitants. The latter bodies are rejected at once; but the food-stuffs are taken up by his veins, incorporated with the blood (which consists of food in different degrees of combustion), and used for building up the various portions of his body. Supposing the animal were a mere growing object like a crystal, with no work to perform and no consequent waste of material, the process would stop here, and the creature would wax bigger and bigger from day to day, without any alteration in place or redistribution of assimilated matter. But the animal is essentially a locomotive machine, and the purpose for which he has taken in his food is simply that he may use it up in producing motion. For a while he stores it away in his muscles, or lays it by for future use as fat; but its ultimate destination in every instance is just as truly to be consumed for fuel as is the case with the coal in the steam-engine.

The food, however, only gives us one half of the necessary materials for the liberation of dormant energy. Oxygen is needed to give us the other half. This oxygen we take in whenever we breathe. Animals like fishes or sea-snails obtain the necessary supply from the water by means of gills; for large quantities of oxygen are held in solution by water, and the needs of such comparatively sluggish creatures are not very great. With them a little energy goes a long way. Air-breathing animals like ourselves, on the other hand, need relatively large quantities of the energy-yielding gas in order to keep up the constant movements and high temperature of their bodies. Such creatures, accordingly, take in the oxygen by great inhalations, and absorb it in their lungs, where it passes through the thin membrane of the capillaries, or very tiny blood-vessels, and so mixes freely with the blood itself. Thus we have food, supplied to the blood by the stomach, the exact analogue of the coal in the engine; and oxygen, supplied to the blood by the lungs, the exact analogue of the draught in the engine. Whenever these two substances—the hydrocarbonaceous foods and the free oxygen—reunite, they will necessarily give out heat and set up active movements.

The exact place and mode of their recombination we can not yet be said to fully understand. But even if we did, the details would be sufficiently dry and uninteresting to general readers; and we know quite enough to put the subject in a simple and comprehensible form before those who are willing to accept the broad facts without small criticism.

We may say, then, that the energies of the body are used up in two principal ways—automatically and voluntarily. The automatic activities are produced by the steady and constant oxidation of some portion of the food-stuffs in the blood and tissues. As this oxidation takes place, it sets up certain regular movements, which compose what is (very incorrectly) known as the vegetative life in animals. There are an immense number of these movements always going on within our bodies, quite apart from our knowledge or will. Such are the beating

of the heart, with the consequent propulsions of blood through the system; the expirations and inspirations of the lungs, which supply us with the oxygen for carrying on these processes; the act of digestion and assimilation; and many other minor functions of like sort. But just as in the case of the steam-engine, so in the human or animal body, the union of the oxygen with the hydrocarbons, besides producing motion, liberates heat. This heat keeps the bodies of birds, quadrupeds, and human beings, which are all very active in their automatic movements, at a much higher temperature than the surrounding medium; while reptiles, fishes, and other "cold-blooded" creatures, having much less energetic motions of the heart and lungs—which of course betokens much less oxidation of food-stuffs—have bodies comparatively little different in warmth from the air or water about them. We thus see in part why it was that the anaconda and the desert-snail could go so long without food; though we can not quite understand that question till we have examined the voluntary movements as well. It should be added that, though the latter class of actions also produce heat—as we all know when we walk about on a cold day to warm ourselves—yet the temperature induced by the automatic activities of the body alone is generally sufficient under normal circumstances to keep us comfortably warm. Thus, while we are asleep, only the actions of breathing and the beating of the heart continue; but the union of oxygen with the food-stuffs to produce these movements suffices as a rule to make bed quite hot enough for all healthy persons; and if we ever wake up cold after a good night's rest, we may be sure that our automatic activities are not what they ought to be.

The voluntary activities of the body are brought about in a slightly different manner. Directly or indirectly, they depend upon the union of oxygen and food-stuffs within the tissues of our locomotive muscles, the energy so liberated being made use of to bend or extend our bones or limbs in the particular way we desire. The muscles always contain (in a healthy and well-fed person) large quantities of such stored-up food-stuffs; and the blood supplies them from moment to moment with oxygen which may unite with the food-stuffs whenever occasion demands. But the union does not here take place regularly and constantly, as in the case of the automatic organs; it requires to be set up by an impetus specially communicated from the brain. That seat of the will is connected with the various voluntary muscles by the living telegraphic wires which we call nerves; and when the will determines that a certain muscle shall be moved, the nerves communicate the disturbance to the proper quarter, the necessary oxidation takes place, and the muscle contracts as desired. We do not quite know how the nerves and muscles perform these functions; but it is pretty certain that the nitrogen of our foods plays an active part in the process, and that, as I have already hinted, it acts in a manner somewhat analogous to that of a match. We may suppose, to put the matter in a familiar form, that

the will sends down a sort of electric spark [1] to the muscle ; and that this spark, lighting up the explosive nitrogen, causes an immediate union of the oxygen with the constituents of muscle, and so produces the visible movement.

Of course, voluntary actions, like automatic ones, liberate heat; but this heat is generally somewhat in excess of what is required for comfort, especially in hot weather. Lower animals, however, which have no fires and no artificial clothing, require it more than we do to keep us warm ; and even we ourselves in wintry weather always feel chilly in the morning until we have had a good brisk walk to set up oxidation, and consequently liberate enough heat to make us comfortable.

Thus all motion, in the animal as in the steam-engine, depends upon the union of oxygen with food or body-fuel. It is true that in the animal body oxygen can unite directly with carbon and hydrogen without the necessity of a high temperature, which we saw was indispensable in the case of the coal, in order to bring the two sets of atoms within the sphere of their mutual attractions. But the difference is probably due to the different condition of the hydrocarbonaceous substances within the animal body ; or else, as others conjecture, to the assumption by the oxygen of that peculiar state in which it is known as ozone. At any rate, the two processes do not disagree in any essential particular, being both cases in which free substances, possessing dormant energy by virtue of their separation and their affinity for one another, unite together, and in so doing liberate their energy as heat and visible motion.

There is, however, one important distinction of detail between the mechanism of a steam-engine and the mechanism of an animal body, which gives rise to many of the mistaken notions as to the use of food which we noticed above. In the engine, we put all the coal into the furnace, and burn it there at once ; while the piston, cylinder, cranks, and wheels are not composed of combustible material, but of solid iron. In the animal body, on the other hand, every muscle is at once furnace, boiler, and piston ; it consists of combustible materials, which unite with oxygen in the tissues themselves, and set up motion within the muscle of which they form a portion. The case is just the same as though the joints of an engine, instead of being quite rigid, were composed of hollow India-rubber and whalebone, with iron attachments ; were then filled with coal, oxygen, and water, and possessed the power of burning up these materials internally and setting up motions in the India-rubber tubings. Hence the materials in the muscles are always undergoing change. The carbon and hydrogen which have united with the oxygen are perpetually forming carbonic acid and water ; and, as

[1] I am speaking quite metaphorically and popularly, and do not mean to imply adhesion to the electrical rather than to the isomeric theory of nervous conduction.

[2] I purposely simplify and omit details, so as to give the reader a graphic and comprehensive picture of the central facts. So long as essentials are not distorted, a good diagram is far better for educational purposes than an accurate facsimile.

these have lost or given up all their energy, they are naturally of no more use to the body than the similar carbonic acid and steam which fly up the draught are of use to the engine. Accordingly, they are taken up by the stream of blood as it passes, separated from the useful components of that compound liquid by an appropriate organ, and rejected from the body as of no further service.

But their place in the muscle must once more be supplied by fresh energetic materials; and these materials are brought to it by the selfsame blood which removes the deënergized waste products. And now we begin to see why we must eat our dinners or starve. Every time our heart beats, every time our lungs draw in a breath, a certain amount of matter in the tissues of the muscles which produced those motions undergoes oxidation, and is carried off in the oxidized form to be cast out of the body as waste. Every new pulsation or breath requires a certain new quantity of energetic material, both as food-stuffs and as oxygen; and hence we must supply the one from the stomach and the other from the lungs if we wish to keep the mechanism going. The store of hydrocarbonaceous matters laid by in the body is generally considerable in well-fed persons; for, besides the contents of the muscles themselves, we have usually a large reserve fund in the shape of fat, ready to be utilized when occasion arises. Hence, we can get along for a very short time, if necessary, without food; because we can fall back, first upon the fat-reserve, and then upon the muscles and tissues, for energetic materials. But after a time the ceaseless beating of the heart and movement of the lungs will use up all the available matters, and the blood will cast off the oxidized product and excrete it from the body; till at last no more materials are forthcoming, the whole contents of the tissues have been oxidized and got rid of, and the heart and lungs must perforce cease to act, in which case the unhappy victim is said to have died of starvation. As regards the supply of oxygen, on the other hand, we are very much more restricted in our power of endurance; for we have no large store of this necessary for combustion laid by in our bodies, and if the supply be cut off for a single moment (as by compressing the throat or suffocating with carbonic acid) the heart and lungs must cease at once to act, and death takes place immediately. For of course death, viewed on its purely physical side, means the cessation of that set of activities which results from the union of oxygen with the food-stuffs in the body.

By this time I hope the reader can see quite clearly what is the necessity for eating his dinner. If we are to live, we must keep up the cycle of our bodily activities, and especially those two fundamental ones, the breathing of the lungs and the beating of the heart. In order to do this, we must supply the muscles employed with the two energy-yielding substances, oxygen and hydrocarbons. The supply of oxygen must be continuous; in other words, we must never for a moment leave off breathing; but the supply of hydrocarbons may be intermit-

tent, though it must be sufficient on the whole to balance waste. We must not regard the object of food, however, as being merely to build up the matter of the body; we must rather consider it as intended to recruit the energies of the body. The more active any creature is, both in its automatic and its voluntary movements, the greater will be the amount of hydrocarbons consumed or used up in its muscles, and the greater, consequently, the amount of food and oxygen which it will require to make up the loss. The tiny humming-bird will need far more food in a year than the great anaconda with which we began our discourse: because the humming-bird has a rapidly moving heart and lungs, while the cold-blooded snake respires and circulates slowly; and the humming-bird darts about perpetually at lightning-speed from flower to flower, while the snake lies coiled up motionless in its blanket from year's end to year's end, or only comes out sleepily now and then to swallow the food which will keep up its vital actions through another long and lazy fast.

The desert-snail, however, can endure much longer without food than even the anaconda, because, like so many other mollusca, it can *hibernate.* This process of hibernation consists in the inducement of a state during which the heart ceases to beat, respiration is suspended, and the animal can hardly be said to live at all. But when warmth and moisture are once more applied, the heart recommences its action, the lungs or gills quicken their movements, voluntary locomotion ensues, and the creature sets out again on the quest for food. Something analogous occurs in the case of the bear, the dormouse, and other hibernating quadrupeds; but in these instances the vital functions continue much more in their ordinary state, and are kept up by the supply of fat which is dissolved by the blood, and consumed in effecting the necessary automatic actions. The bear, which goes to sleep in the autumn as sleek and plump as a prize pig, wakes up in the spring a poor, lean wretch, with only just flesh enough to cover his bones, and carry him off in search of fresh food. The much more complicated mechanism of the higher animals requires to be kept always in action; it can not cease almost entirely, like that of the snail, and then revive again when circumstances become more favorable. Hence hibernating mammals must lay by fat during the summer to keep their principal organs at work during the long winter fast. Yet, even among human beings, cases of "trance" or "suspended animation" occasionally occur, during which the cycle of vital actions almost entirely ceases to all appearance for a considerable time, and then begins again on the application of some external or internal stimulus—which latter may be not unaptly compared to the slight shaking which we sometimes give a watch or clock to set it going when stopped by a momentary impediment. Persons recovered from drowning, in whom the cessation of action has been quite sudden and has not affected the structure of their organs, are often thus restored by the judicious use of rubbing and alcohol.

The camel presents a more interesting phenomenon in his well-known humps. These protuberances consist really of reserve-stores of fat, which the camel uses, not only for keeping up the action of his heart and lungs, but also for producing locomotion in his frequent enforced fasts among the deserts of Arabia or India. The humps dwindle away as he marches, in a manner exactly similar to that of the bear's fat during his hibernation, only of course much more rapidly, as they have so much more work to perform.

Finally, it may appear strange that the small amount of food we eat should suffice to carry our large and bulky bodies through all the varied movements of the day. But this difficulty disappears at once when we recollect how large an amount of energy can be laid by dormant in a very small piece of matter. A lump of coal no bigger than one's fist, if judiciously employed, will suffice to keep a small toy-engine at work for a considerable time. Now, our food is matter containing large amounts of dormant energy, and our bodies are engines constructed so as to utilize all the energy to the best advantage. A single gramme of beef-fat, if completely burned (that is, if every atom unites with oxygen), is capable of developing more than 9,000 heat-units; and each such heat-unit, if employed to perform mechanical work, is capable of lifting a weight of one gramme to a height of 424 metres; or, what comes to the same thing, 424 grammes to a height of one metre. Accordingly, the energy contained in one gramme of beef-fat (and the oxygen with which it unites) would be sufficient to raise the little bit of fat itself to a height of 3,816 kilometres, or about as high as from London to New York. Again, it may seem curious that the food eaten by the anaconda in South America, and stored up in its tissues, should suffice to keep up the action of its heart and lungs for so many months. But then we must remember that it performed very few other movements, most probably, during all that time; and if we think how small an amount of energy we expend in winding up an eight-day clock, and how infinitesimal a part of our dinner must have been used up in imparting to it the motion which will keep it swinging and ticking for one hundred and ninety-two hours, we can easily understand how the large amount of stored-up energy in the snake's muscles might very well serve to keep up its automatic actions for so long a time.

There are five hundred other little points which this mode of regarding our bodies at once clears up. It shows us why we are warmer after eating a meal, why cold is harder to endure when we are hungry, why we need so little food when we are lying in bed inactive, and so much when we are taking a walking tour or training for a boat-race, why cold-blooded animals eat so rarely and warm-blooded creatures so often, why we get thin when we take too little food, and why we lay on fat when we take too little exercise. But these and many other questions must be passed over in silence, or left to the reader's discrimination, lest I should make this paper tediously long. It must suffice for the

present if I have given any of my readers a more rational reason in future for eating their dinners. To be sure, Nature herself has admirably provided that even the most unscientific person should find sufficient internal conviction as to the desirability of dining without the aid of extraneous exhortation; but it is at least some comfort to know that so universal and so unreasoning a practice is not altogether an unreasonable one as well.—*Belgravia.*

THE ORIGIN OF UPLAND LAKES.

By Rev. J. CLIFTON WARD, F. G. S.

WHO has not felt a sudden and intense pleasure when, rounding the end of some mighty mountain or towering crag, the still waters of an upland lake or tarn have first met the eye? Perhaps, on approach, wild birds have started from the smooth surface and left it a little sea of shimmering gold, as the sun's light has been reflected from each tiny wavelet. The raven's croak among the overhanging cliffs, the patch of snow lying unmelted deep in a rocky fissure, the scattered sheep browsing carelessly on the few grassy slopes, while all around are masses of tumbled rock, and the light veil of cloud that ever and anon sweeps the cliff-tops and adds an air of mystery and wonder to the whole—all combine to make a scene which can not but send a thrill of pleasure and perhaps of happy awe to every heart. Instinctively one feels, if the power of expression be not present, what Nature's true poet hath so truly sung:

> . . . . How divine
> The liberty, for frail, for mortal man,
> To roam at large among unpeopled glens
> And mountainous retirements, only trod
> By devious footsteps; regions consecrate
> To oldest time! and, reckless of the storm
> That keeps the raven quiet in her nest,
> Be as a presence or a motion—one
> Among the many there.

No one can wander over rugged and beautiful mountains without being led to love and admire these calm sheets of water, which lie nestled in hollows, and are ofttimes blackened by the shadow of encircling cliffs. Love for such solitary spots soon excites our curiosity as to the origin of these miniature upland lakes. In the Cumbrian lake district they are scattered broadcast over the country in far greater numbers than most people imagine, and at a period not vastly remote their number must have been more than double what it is now. But the yearly waste of mountain-side and the matter brought down by

every stream have filled up many a mountain pool, and frequent peat-mosses mark the spot where once the waters danced in the mountain breeze. Whence these hollows? What is their origin? Do we see in them the relics of volcanic effort? Are the combs (*cwm*), coves, or corries in which they lie the vestiges of volcanic craters, as the form of many at first, perhaps, suggests? Or have we here hollows produced directly by surface action? Again, are these hollows of great depth, or are they shallow? What is their general form? Now, there is little doubt that most people, if asked to draw the form of the hollow in which the waters of a tarn now lie so placidly, would grossly exaggerate its true depth, or perhaps liken it to the basin formed by placing the two hands together, side by side, curved, with the palms uppermost. Some years since I took a number of soundings among the Cumbrian lakes and tarns, and communicated the results of my examination to the Geological Society ("Quarterly Journal of the Geological Society," vol. xxx., p. 96, and vol. xxxi., p. 152). Hold out one hand, palm uppermost, and straighten it as much as possible—the hollow in the palm is yet far too deep to represent with truth the natural rock basin. Soundings taken in lakes throughout the district all show the same thing—the basins are very shallow compared with their size and the height of the surrounding hills.

Next, let us search out the origin of these shallow basins. At the outset we distinguish two classes of action, one of which must have been at work. Either the matter formerly filling the hollow has been dug out and carried away by some agent working at the surface; *or* force from below has here sought a vent, and dispersed the matter far and wide; or, from failing support, the ground has sunk at this spot into a hollow.

First we will consider the upward or downward theory. If these numerous mountain hollows, with included tarns, be of volcanic origin, then it is clear we shall find the *signs* of a crateral hollow such as we see them in many parts of the world at the present day. There are no such signs. It is true that in many cases the surrounding rocks are of volcanic origin; but the volcanic beds, in their lie and position, show no manner of relation to the tarn-hollows; and a little study of the rocks of the district and the form of the ground clearly shows that the volcanoes which gave rise to the ashes and lavas forming many of Cumbria's highest mountains, were active, not as but yesterday, but in untold ages past. Then, as to the *downward* or *special depression* theory, when we can conceive such minute subsidences taking place at a great number of almost microscopic spots without affecting the rocks around, or leaving any evidence of a sinking away, we may admit it as possible.

If not produced by expulsion of matter outward or sinking of matter inward, these hollows must be the effect of some surface-working agent. The sea *planes* away along the coast-line, and the material goes to *fill up* ocean-hollows; therefore the sea can not be the agent,

and any force in an ocean *current* is clearly out of the question over these scattered *spots*. Streams and rivers work along lines, form ravines and gorges, but never a more or less circular basin of great size in comparison with the stream, or river; hence they can not be the agents. The atmospheric powers—rain, snow, wind, and chemical action—weather the rocks indeed, form tiny basins on almost every stone; but this is but nature's fretwork, the delicate carving around the sculptured craggy tower or spire and smooth-scooped rocky front. Yet there is one surface agent remaining, the moving glacier. Most people are familiar with the proofs of former glacial action in Cumberland and Wales—proofs as clear as are those of the former greater extension of the Swiss glaciers. Now by far the greater number of our tarns lie in true rock basins—hollows completely inclosed by rocky sides, which are, moreover, smoothed and grooved in a manner peculiar to ice-action. At the sides of many a tarn and lake you may see the ice grooves and scratches passing beneath the water, so as to leave no doubt whatever that ice has once occupied the rocky hollow. The question is, Did the ice-movement form the hollow? I believe that in most cases it did, and for these reasons: 1. The tarn lies almost invariably in the path of old ice streams or glaciers, as is proved by the direction of the scratches in the surrounding rocks. 2. They *frequently* occur at the foot of slopes more or less steep, or where the ice-pressure can be shown to have been great. 3. The position of the deepest points in the larger tarns and lakes occurs almost invariably where, from the confluence of two or more glaciers or the narrowing of the valley, the ice-pressure must have been somewhat increased. 4. The depth of these tarns is very slight as compared with the thickness of the ice which can be proved to have passed over them. 5. There is every gradation from a tiny, rock-bound pool, glaciated on all sides, and which all will admit must have been scooped out by the ice, to the tarn or lake showing precisely similar phenomena on a larger scale.

Since the ice-plow passed over our land the atmospheric powers have been at work for a long period; and while many rock basins are now completely filled up by stream-borne matter, all are *being* so filled, and each age must witness a decrease in the number and size of those sheets of water which form so marked a character of our Cumbrian scenery.

Before quitting this subject, however, I must remark that there are a few tarns which seem to me to owe the whole or a part of their depth to a moraine dam. That is to say, the rock basin is imperfect on one side, and there an old glacial moraine may have helped to dam the waters back ever since the retreat of the glacier which threw off the moraine. It frequently happens that a little moraine material has been left upon ice-rounded rocks at the foot of a tarn, and in such cases a hasty observation might lead one to believe that the whole

mound was a moraine. Let us remember, then, that a tarn may lie in a complete rock basin, ice-formed; in a glaciated hollow dammed on the lower side by a moraine or other accumulation of rocky *débris;* or it may owe part of its depth to a rock-inclosed hollow, and part to a morainic dam. Therefore, on a summer's day, as we lie dreamily gazing upon the rippling waters of these mountain tarns, we may sometimes think of an age which is past, when the ice-sheet moved majestically over the now heather-clad fells, and all the country lay "clad in white samite, mystic, wonderful."—*Popular Science Review.*

SKETCH OF SIR HUMPHRY DAVY.

HUMPHRY DAVY, one of the world's greatest chemists, and the discoverer of the electric light, was born December 17, 1778, at Penzance, in Cornwall. His father, a wood-carver and gilder by trade, died in 1794, leaving his widow and five children, the oldest of whom was Humphry, in destitute circumstances.

Humphry was a strong, active, healthy child, and gifted with a singularly retentive memory. Sent to an elementary school at the age of six, he made such rapid progress that soon the master had him transferred to the town grammar-school. In his boyhood he manifested a strong liking for open-air sports—riding, fishing, shooting, and the like—also for making collections of natural-history specimens. This bias was anything but pleasing to his teachers and guardians, who feared that, unless he gave more time and attention to his book-lessons, he would grow up to be a ne'er-do-well. Fishing was his favorite amusement. When a little child he was to be seen after every rain—and rains are exceptionally frequent at Penzance—fishing in the street-gutters. At nine years of age he went to live in the household of a Mr. Tonkin, a friend of his mother's family, resident at Varfell, a little village in Mount's Bay. The site of Varfell is a charming one, and the surrounding country is rich in minerals. Young Davy, who was of a poetic temperament, was at home in this delightful nook, and what with his shooting, fishing, and collecting, his days were full of enjoyment. Evidently he loved nature rather than books, and though his guardian feared that his studies—if study that may be called which was all play—were taking a wrong direction, he was in reality acquiring the rudiments of a very solid education—acquaintance with nature's ways. The little child who fished in the gutters of Penzance later wrote that charming work, "Salmonia, or Days of Fly-Fishing," wherein, mingled with notes of his piscatorial exploits in the trout-streams of the Austrian Alps, are philosophical reflections on the deepest problems of the universe. As a boy he loved to roam among the hills of his native

Cornwall; in the fullness of his fame he was passionately fond of traveling, and his latest book was "Consolations of Travel"—the work of a dying Plato, as it was called by Cuvier.

On the death of his father, Davy, who was then just entering on his sixteenth year, was apprenticed to Mr. Borlase, apothecary and surgeon of Penzance. He now resolved to begin a systematic course of study, literary and scientific. In his boyish ardor, the task he set himself was nothing less than the acquisition of universal knowledge. His MSS. of this period contain the germs of many of the thoughts which found more perfect expression in his maturer writings. In his notebooks, a voluminous collection of which he left behind him, he was accustomed to make a record of every chance observation, and of every more important thought which occurred to his mind. Says a writer in the "Chemical News," to whom we are indebted for many of the particulars of Davy's career contained in the present sketch: "Observations of every kind and sort are included in these pages. At one time he notes down a peculiarity of flight in a swallow, at another a philosophical or theological puzzle, at another the anomalous behavior of certain reagents, with a view to further investigation; whatever, in fact, he observes, down it goes for future reference or consideration."

In 1796 he read Lavoisier's "Elements of Chemistry," and so was led to the experimental study of that science, in which later he attained the highest eminence. The following year he began to write his "Researches on Light and Heat," published in 1799. One of his first chemical researches had for its object to determine the nature of the air which fills the vesicles of common sea-weed; and he demonstrated that the marine plants act upon the air precisely in the same way as the terrestrial, by decomposing carbonic acid under the influence of the sun's rays. These physical and chemical researches won for him in 1798 an invitation from Dr. Beddoes, director of the "Pneumatic Institution" at Clifton—a sort of hospital for the treatment of pulmonary diseases by the inhalation of different gases—to become his assistant. Having removed to Clifton, Davy made use of the facilities which the Pneumatic Institution afforded for studying the physiological effects of various gases—as nitrous oxide (laughing-gas), carbonic acid, nitrogen, etc. These experiments more than once came very near being fatal to the venturesome young chemist, and indeed his health was seriously impaired, so that he was forced for a time to intermit his researches. While at Clifton he also took up the subject of galvanism, and thus laid the foundations for his brilliant discoveries in electro-chemistry.

In 1801 Count Rumford offered him the position of lecturer on chemistry in the London Royal Institution, which he had recently founded. This post he held for one year, and then was formally appointed Professor of Chemistry in the same institution. Davy was a remarkably handsome man, of good stature, gifted with great eloquence, and above all an enthusiast. His lectures at once became the

talk of the town, and the highest ranks of society began to throng the theatre of the Royal Institution whenever Davy was announced to give a lecture. He was, as the saying goes, the lion of the metropolis, and was carried away by the tide of fashionable life. During the hours of the day he attended to his duties at the Royal Institution, and pursued his scientific researches with the same ardor as ever, but he "devoted the evening to social intercourse with the aristocracy of birth and brain, with all the thoroughness of his nature."

In 1802–'3 he delivered a course of lectures on agricultural chemistry. These lectures were afterward published under the title of "Elements of Agricultural Chemistry," and the work passed through many editions at home, besides being translated into almost every language of Europe. His observations on the chemistry of tanning were published in 1803 in the "Philosophical Transactions." His researches on electro-chemistry, begun at Clifton, were continued at the Royal Institution. His two famous "Bakerian Lectures," the first on the laws of electricity in relation to chemical combination, and the second on the results of the application of these laws, were delivered in 1806 and 1807 respectively. He discovered the base potassium October 6, 1807; sodium and other bases soon afterward. We are told that "when he saw the globules of potassium appear and take fire as they entered the air, his delight was so great that for some time he could not compose himself sufficiently to continue the experiment." Indeed, his mental labor and the excitement over his discoveries had such an effect on his general constitution, that for several weeks he lay seriously ill. On his recovery he presented to the Royal Institution the battery of two thousand cells with which he had made these great discoveries. It was with this battery that, in 1813, he produced for the first time the electric light. When the current from this pile was passed between two pointed pieces of wood charcoal, attached to conducting wires, a light was produced of such dazzling brilliancy as to be comparable only with sunlight. The length of this electric arc was four inches.

In 1803 he was elected a Fellow of the London Royal Society. He was knighted in 1812, and the same year married a wealthy widow, Mrs. Apreece. His "Elements of Chemical Philosophy" were published this year. He now resigned his professorship at the Royal Institution, and in the following year visited the Continent of Europe. At Paris he was received with distinguished honor by the Academy of Sciences, and demonstrated to that august body that iodine is an element. He remained abroad some two years, in the mean time diligently pursuing his chemical researches. At Florence he investigated the nature of the diamond, which he proved to be an allotropic form of carbon. His researches on colors and on the iodine compounds were also carried on during this period.

In 1815 he made the tour of Scotland, and on his homeward journey visited the coal districts of England. A committee of colliery propri-

tors waited on him to induce him to study the causes of the numerous explosions of fire-damp which were annually attended with fearful loss of life. He began his investigation by analyzing the gas and ascertaining in what proportions its mixture with air renders it most explosive. Having observed that the combustion was not communicated through tubes of small dimensions, he gradually reduced the length of the tubes till he found that a simple metallic gauze, with spaces not exceeding $\frac{1}{22}$ of an inch square, was sufficient to prevent the burning gas on the one side from igniting the explosive mixture on the other. On this principle he constructed his "safety-lamp."

At the recent celebration of the centenary of Davy's birth, held at his native town of Penzance, it was remarked by one of the orators, a colliery proprietor, that but for the discovery of Davy's lamp some of the best seams of coal in England would have remained unworked, or could only have been worked at such cost that none but the rich could afford to use coal. "Davy's lamp," he further said, "is still the best, and if properly constructed, and used in conjunction with efficient ventilation, is an infallible guide to the presence of dangerous gases."

Urged to have his lamp patented, Davy made this noble reply: "My sole object was to serve the cause of humanity; and if I have succeeded I am amply rewarded in the gratifying reflection of having done so." In 1817 the colliery owners and miners of England presented Davy with a magnificent service of plate worth £2,500. This was bequeathed to the Royal Society by Lady Davy, who directed it to be sold and the proceeds applied to the encouragement of science.

In 1818 Davy was created a baronet. The same year he again visited the Continent, traveling extensively in Germany, Hungary, and Italy. The possibility of unrolling the Herculanean papyri engaged his attention while in Naples, and he published observations on volcanic phenomena, and on Oersted's electro-magnetic experiments. He was elected President of the Royal Society in 1820, and held that office for seven years. In 1823 he succeeded in devising a method of preventing the corrosion of the copper sheathing on ships' bottoms.

He now fell into ill health, and but little scientific work was done during the remaining years of his life. Three or four times he visited the Continent, but received little benefit from the change of scene and of climate. He died at Geneva, May 29, 1829, and there, in accordance with his own wishes, was buried. His widow founded a prize in his honor, to be awarded biennially by the Geneva Academy of Sciences for "the most original and important discovery in chemistry."

EDITOR'S TABLE.

SCIENCE IN RELATION TO WAR.

HOW the art of war, by the powerful stimulus it has given to the investigation of the properties of projectiles and numerous kindred researches, has been an efficient promoter of progress in physical science, is well understood. The strife among engineers to construct guns that shall be able to pierce any barrier, and to construct barriers that shall resist all guns, has led to results in improving the quality of metals which could hardly have been gained in any other way.

It is not, however, this aspect of the science of war that here interests us; but rather its ethical side, or the excuses that can be offered for it as a part of the policy of Nature. An English writer * has recently gone into the subject, and attempted a scientific defense of the general and permanent habit of war which it is important to notice, in order that science may not be perverted to false and injurious ends.

The writer with whose views we are now concerned points out in an interesting manner in what way science has operated to alleviate the horrors of war, to shorten its duration, and temper its effects. He remarks that in the days of the old smooth-bore, when it was a maxim not to fire till the whites of the opponents' eyes were visible, it was said to take a man's weight in lead and iron to kill him, so many bullets and cannon-balls were fired ineffectually; but now, owing to the increased distance at which firing takes place and to the general use of earthworks, it is still more difficult to do execution. The statistics given by the writer strongly corroborate this view. He says the average number of killed and wounded on both sides in the great Napoleonic battles taken collectively was a little over one fourth of the whole forces engaged; while the average in the great European battles fought within the last thirty years, since the general introduction of arms of precision, gives a little less than one twelfth. We are also reminded that the more improved modern warfare engenders less hatred between the conflicting parties. "Before the invention of gunpowder, when fighting was conducted at comparatively close quarters, soldiers fought with an animosity which is now rarely seen. The man who was to take your life unless you took his, projected himself before you dangerous and hateful, but under the present system wounds seem to come from some impersonal agency; a man is less vividly impressed with the personality of his foe, who, like the Ethiopians, is blameless because he is far away, and whose individuality is lost at the distance of a quarter of a mile, where he is taking shots at you from behind a hedge. But in ancient times great bodies of men once interlocked in conflict could not be drawn off till utterly exhausted with mutual slaughter, and hence we read of such battles as Cannæ, where on the Roman side alone, according to Polybius, out of 86,000 men not much more than 15,000 prisoners or fugitives came off unhurt; and Cressy, where there perished of the French on the field or in the pursuit between 30,000 and 40,000 men—battles in which the wounded and disabled experienced in butchery that cruelty to which in brave minds the frenzied fears attending close conflict can alone give rise."

Our new philosopher of war is quite ready to concede its evils, its calamities, and its horrors—its terrible waste of

* "The Philosophy of War," by James Ram.

treasure, blood, and life. He says millions of men all over Europe are at this moment idling away their time in demoralizing barrack-life, trained among much physical and mental deprivation to no art but that of destroying each other skillfully, which is much as if they had been usefully employed and the products of their labor then cast into the sea. We are reminded of the immense amount of work bestowed upon a first-class ironclad, which is liable to be sent to the bottom in an instant. She may have cost $2,000,000 and her equipment another half million; so that if the ordinary laboring man earns $250 a year, on the average of twenty years of working life we have the whole life's labor of 500 men destroyed by the single loss of such a ship. Blood and health are precious; war spills the former and impairs and destroys the latter on an appalling scale. As to the waste of life, it is of course incalculable; yet, if there be a money estimate of it, the result is shocking. Laboring men are capital in society, and it is a very moderate estimate to assume them from this point of view as worth $2,500 a piece. A battle, therefore, in which 20,000 men are killed, annihilates $50,000,000 of capital in human beings alone.

The sufferings of war are conceded to be indescribable. Mr. Ram remarks: "Of all incidents of battle the one which impresses itself most strongly on my imagination is that of Borodino, where 60,000 French and Russians were left upon the ground; the groans of the wounded in the ensuing night sounded at a distance like the roar of the sea. The far-off listener might expect to hear outcries of pain and distress from such a scene, that screams of agony should arise from instant to instant, and that the doleful, piercing note should be taken up from this point and from that, and that night should be made hideous by this inarticulate misery. But here was no such intermittent lamentation. From amid 20,000 corpses arose a hoarse, uniform, unceasing roll of the anguish of 40,000 men!"

How, then, are we to regard these practices? Our author says that we must turn to Nature to find how she regards such things. Is war an exception to her course, or does she regard men fighting as a naturalist looks on tribes of ants destroying each other? The answer is, that Nature is absolutely pitiless. Her eyes never fill with tears. She multiplies to destroy, and destroys without mercy.

"Her taller trees debar the meaner shrubs from sun and breeze. It is nothing to her that the more lowly plants in the forest wither and pine for light and air. It is her will that the weakest should go to the wall. Ravin is the condition of the existence of half her creatures; and at this moment, as all around this sea-girt ball the strong animals prey upon the weak for their daily sustenance, more skins are being pierced and torn, more bones being crushed, more blood being shed, in the far-off places of the earth than twenty Russo-Turkish wars going on together would involve. Are we to be told that Nature enjoins these things, and yet is outraged by men tearing and rending each other? Still she is not simply indifferent. She appears to have a purpose in all this. She knows that the world is not rich enough for all. She keeps it upon principle in a condition of over-population. She thinks it better that the strong should crowd out the weak than that the weak should crowd out the strong by mere dint of numbers under any protective system. She seems to desire the greatest good possible in the world, and her means to this end is the selection of the fittest, with the extermination of the less fit; the selection of the most highly organized in body, which includes the most highly organized in mind. In her care for the type she disregards individual men and individual races.

"The excellence of man himself is

the outcome of continual fighting among species of anthropoid animals involving the continual destruction of the weaker by the stronger and the constant selection of the fittest to survive. It is curious to note that it is not those most distantly below us in the scale that we are chiefly eager to destroy. It is generally those who more nearly approach to us in gradation and who consequently clash with us, that we destroy. Those whose complete inferiority prevents us from fearing them escape. At the present time, Nature is doing much more by human agency to destroy Red Indians and native Australians than to exterminate gorillas. No links have so great a tendency to disappear altogether as those which are nearest to ourselves in the chain. As man ascends the ladder he kicks off those who stand on the next step below him. This habit has in time created an immense gap between us and some of those through whose condition our race has once passed—a gap so wide as to make it almost impossible for any but studious men to realize that there is indeed any solidarity between us and the lowly forefathers ascribed to our species."

There is much truth, no doubt, in this view of the operations of Nature, but it is far from the whole truth as relates to the morality of war. It certainly will not do to excuse private violence and offer a defense of crime on the ground that Nature is also ruthless and violent. And if individuals may not plead the example of Nature to justify their injurious interference with others, neither may nations. That war was indispensable in the lower stages of society when brute force predominated, and became a means of enforcing those subordinations which led to social order, may be freely admitted. But if old practices are to go on for ever, what becomes of progress? The essence of evolution is transformation—the substitution of higher agencies for lower in the unfolding economy of the world. War is one of the things that must certainly be left behind if there is to be any advancing or upward movement. It is the old and deadly enemy of the pacific and constructive forces of society, which have nevertheless made way against it, and which may be expected in the future to gather a strength that will redeem society from the baneful influence of the military spirit.

AN HISTORIAN'S NOTION OF LINGUAL STUDY.

We referred last month to the revival of the old classical controversy consequent upon the proposal to drop compulsory Greek from the curriculum of the University of Cambridge, in England. The controversy grows warm in various quarters. Mr. Freeman, the historian, comes forward in the "Fortnightly Review" to discuss the question, "Shall we give up Greek?" and uses the occasion to go into the general subject. He regards the present spasm of controversy as not very serious, inasmuch as he has had experience of such things before, and thinks it is merely part of a system of curious intellectual cycles, the causes of which would perhaps form fit subject for the philosophical statistician. Mr. Freeman says there was a sharp brush over the question in 1871, in which he took a part, and that we are now engaged in merely reproducing the old arguments and the old answers.

But Mr. Freeman betrays, in his treatment of the subject, the consciousness that it is advancing, and that these rhythmic disputes are bringing about very serious changes of opinion. He pleads strongly for Greek, but seems to feel that it is doomed, and is decided in his conviction that, if but one of the classical tongues is to be retained, it must be Latin.

His general position in relation to the question is much the same as that so elaborately put forth by John Stuart

Mill in his celebrated St. Andrew's discourse; in both cases we are presented with a grand picture of the intellectual advantages derivable from the acquisition of many languages, and their comprehensive philosophical study. Against this, as we have often said, there is, in itself, nothing to urge. It is an entirely proper thing for men of capacity, whose tastes lead them in this direction, to give their lives to linguistic philosophy, and the acquirement of many languages. But, for ordinary students in college, this is simply futile and impossible, and we have here the perpetual fallacy of the advocates of classical studies. Experience in the universities of all countries and for centuries, and everywhere attested to-day, assures us that this ideal classical accomplishment is not attained, nor anything approaching it. Mr. Freeman says: "If Greek and Latin study could never come to anything more than that kind of scholarship which in its highest form corrected the text of a Greek play and made Greek iambics and Latin elegiacs—which in its lowest form turned out that fearful form of bore which is ready at every moment with a small scrap of Horace or Virgil—if this is all that comes of Greek and Latin study, we might be tempted to say, Perish Greek and Latin study!" But what else do we get, or can we get, but that sort of scholarship from the great mass of students in colleges? He thinks that teaching can be improved so as to yield better results, but that has been the illusion of hundreds of years. The failure and defeat of classical studies has been the opprobrium of the universities for generations, and from the time of Milton to the present there have been loud calls for reform and improvement in the modes of classical instruction; but the changes have not come, and the old results continue, nor is any such reform possible. The vice of our system of higher studies is the enormous disproportion between the study of language and the period allowed for education, or even the common length of life. Mr. Freeman says: "I believe, then, that if we can only learn all tongues in a rational way, we may keep our Greek and our Latin, and bring in our German, our French, our Italian, above all our English, in their due places alongside of them." Two results must ever follow from the attempt to realize any such ideas in practice: First, such a predominance of lingual study must effectually exclude all other most important subjects from the curriculum; and, second, the acquisition of the languages themselves will generally be so miserably imperfect that the higher ends aimed at will not be reached. At the foundation this acquisition of languages is a problem of cerebral dynamics. The learning of a language exhausts a very considerable portion of the plastic power of the brain. The acquisition of six languages is, of course, a still more enormous draft upon the cerebral energy, and there must be very considerable native capacity if so many forms of speech are *thoroughly* acquired so as to be brought into relations of critical comparison for philological purposes. Not one student in twenty, nor indeed one in a hundred, will ever do this, and the great mass of them will fall so lamentably short of it that the time given to the study is essentially wasted. Let languages, ancient and modern, living and dead, be pursued to any extent by those who are drawn to the study and propose to devote themselves to this line of scholarship. What we protest against, and what the common sense of the age undoubtedly condemns, is this tenacious and self-defeating ascendancy of extinct languages in the higher education of our youth at large.

We say "extinct" languages, but Mr. Freeman does not like this idea at all. He objects to regarding Greek and Latin as "dead, ancient, classical." He would abolish the current distinction

between antiquated and recent—the living and the dead. He says, "I claim for the Greek tongue its place on the exactly opposite ground—because it is not dead but living, because if it is ancient, it is mediæval and modern no less." This is a new argument for the so-called ancient and dead languages that they are not as ordinarily characterized, but are in reality living and modern. And what else is it but the nonsensical makeshift of a hard-pushed advocate? If the Greek and Latin tongues are still living, why not the Greek and Latin nations? If these languages are not ancient, is there anything ancient? The course of nature goes on, and materials of all kinds are used over and over again in unbroken continuity, but because the present is thus born of the past, are we to forget the distinction between the living and the dead. If the ancient languages are modern, then of course ancient history, and ancient philosophy, and ancient art, are modern history, modern philosophy, and modern art, and there is no end to the stupid confusion. We can hardly congratulate Mr. Freeman on his defense of the cause he has espoused, and have referred to it merely as illustrating the best that can be said by a distinguished historical writer in defense of old academical superstitions.

LITERARY NOTICES.

Journal of a Tour in Marocco and the Great Atlas. By Joseph Dalton Hooker, K. C. S. I., C. B., Pres. R. S., Director of the Royal Gardens, Kew, etc.; and John Ball, F. R. S., M. R. I. A., etc., with an Appendix including a Sketch of the Geology of Marocco, by George Maw, F. L. S., F. G. S. Macmillan & Co. 1878. Pp. 489. Price, $6.50. Illustrated.

The territory of Marocco, which is larger than Spain, and is within six days' sail of England, extends along the Mediterranean from Algeria through the straits of Gibraltar to the Atlantic Ocean, and southward to nearly opposite the Canary Islands, having a coast-line of fully nine hundred miles. Although so near to Europe, this country, beyond its coast, is among the least known regions of the earth; but it is supposed to reach far into the Great Desert on the southern side of the Great Atlas range. It has been called the China of the West, but it is even more isolated and impenetrable than China itself. This scientific expedition to Marocco was undertaken at the beginning of April, 1871, and lasted till the middle of June, but for various reasons the account of it was not published till 1878. Delay of publication, however, can make no difference in the case of Marocco, where it seems there has been little change during the last two centuries. For a long time Sir Joseph D. Hooker had wished to explore the range of the Great Atlas, to learn whether its vegetation furnished connecting links between that of the Mediterranean and the peculiar flora of the Canary Islands. Maw had already made collections of living plants along the coast of Marocco, and had pushed farther into the interior than any but one preceding traveler, and Ball had visited the country in 1851, but its disturbed state made all exploration impossible. Now, however, through the intervention of the Foreign Office, the Sultan of Marocco gave permission for the visit of these distinguished travelers, and on the 7th of April they reached Tangier, one of the most important towns of Marocco, thirty-five miles from Gibraltar, on the coast of the Mediterranean. It is the residence of the diplomatic agents sent from other countries, and consequently the Moorish authorities are somewhat under the control of civilized opinion, and life and property are tolerably secure. Its neighborhood is the only part of all Marocco where a naturalist can wander without an escort of soldiers, and hence little was known of the flora of the empire, except collections from the Djebel Kebir or Great Mountain just west of Tangier. Before going to south Marocco, it was needful for their safety and success that the travelers should have an autograph letter from the Sultan, to prevent the local authorities from defeating their purpose. They had to wait several days for this document, and spent the interval in exploring the Lesser Atlas, with results of ex-

ceeding interest, which are set forth in the second chapter of the work. The Sultan's letter at length arrived. It was written "on a small sheet of inferior paper, folded to the size of a note, and sealed with coarse sealing-wax." It was addressed to the Governor of Mogador, and ran thus: "On receiving this, you will send the English *hakeem* and his companions to the care of my slave, El Gradui, to whom I have sent orders what to do." This slave was the Governor of that portion of the Great Atlas which it was desired to explore. They started at once for south Marocco, and reached the port of Mogador on the 26th. Thanks to the Sultan's letter, the Governor provided for their safety and comfort during their journey across the plains from Mogador to Marocco. They had time to study the region about Mogador, and their observations, meteorological, geographical, zoölogical, and ethnological, as well as botanical, are recorded in Chapter IV. Chapters V. and VI. narrate the journey from Mogador to Marocco. The six following chapters are devoted to the exploration of the Great Atlas. Chapter XIII. describes their second stay at Mogador, their return to Tangier and England, and Chapter XIV. discusses the future prospects of Marocco. The narrative from first to last is one of absorbing interest, not only to botanists but to readers of all classes. The maps and pictures add greatly to the interest and value of the work. It is scarcely possible in the space at our disposal to give any fair idea of the work by means of extracts. The great ability and experience of the authors are evident not only in the delightful and instructive account of each day's proceedings, but equally in the reflections scattered throughout the volume upon numerous subjects, suggested by the physical, social, and political aspects of this strange country. For instance, in speaking of the climate of north Marocco, we have the following:

> Nothing is more rare than to find a country where neither the natives nor foreign visitors have any complaint to make against the climate, and in this respect Marocco is almost unique. As regards the season of our visit, however, our case was that of nearly all travelers in whatever country they may find themselves. We had arrived in an exceptional season! How often is this fact gravely stated as something remarkable and unusual in the experience of the narrator, whereas, if he would but reflect, it merely represents the common experience of mankind in most countries of the earth! Excepting some portions of the equatorial zone, where the seasons recur with tolerable constancy, our notions of the climate of a place are got at by taking an average among a great many successive seasons. Any one who watches the meteorological notices, published in our newspapers, must be aware that if any particular day, week, or month be compared with the general average for the same period during a long term of years, he will find it considerably hotter, or colder, or drier, or moister, than the corresponding average day, week, or month; and, when registers have been kept for a sufficient time in other countries, the same result will be seen to hold good. Travelers will then be prepared to find that they should expect to enjoy, or suffer from, an exceptional season, and will think it more remarkable when they happen to alight on a season near to the average.

We also note the following hint to travelers:

> The net result of our short excursion was not large or brilliant; but, in the case of a country so little known as Marocco, the interest of his collections to a naturalist does not mainly depend on the rarity or novelty of the objects he may happen to meet. Each plant or animal carried away contributes an item of information respecting the distribution of the organized world, the value of which it is impossible at the time to estimate. Travelers who happen to visit little-known countries would do well to remember that with the most trifling trouble they may make useful contributions to natural science, by preserving specimens of the most insignificant-looking objects, provided always that these are afterward placed in the hands of competent naturalists.

International Scientific Series, No. XXV. Education as a Science. By Alexander Bain, LL. D., Professor of Logic in the University of Aberdeen. New York: D. Appleton & Co. Pp. 453. Price, $1.75.

In the maturity of his studies as an original investigator of the science of mind, and in the ripeness of his experience as a practical teacher in the higher sphere, Professor Bain has suspended the course of his customary work to prepare a little treatise on education, and we have no doubt that, as it is the latest, so it will be regarded as the best and most valuable, of his books. Less formidable than his elaborate volumes on "The Senses and the Intellect" and "The Emotions and the Will," the new book is still very full, and brings us to the more important application of the views contained

in these works. In so far as education depends upon principles, it is capable of being dealt with as a science; and, though a practical art, yet like all other arts it must be pursued by blind habit or under rational guidance. We have pointed out again and again in this "Monthly" how the science of mind has been widened in modern times so as to include its corporeal conditions, and thus bring the living being into view as a psychical organism rather than the mere abstraction of mind. This is the method of the modern psychology, the immense superiority of which over the old mental philosophy is most apparent in the field of education. We know nothing of mind except as manifested through its organic machinery. When we consider mind as mental force, it at once becomes complicated with the bodily energies, and it appears under limited and quantitative laws, which it should be the first task of the teacher to master. Mind and body are developed together, and the former can not be intelligently *led out* except under inflexible corporeal restrictions. Professor Bain's long familiarity with this point of view has specially and eminently qualified him to prepare a practical manual of school culture that treats educational questions in detail in harmony with the present state of knowledge.

It is impossible to give anything like an adequate analysis of this admirable work within the limits of an ordinary literary notice, nor, indeed, is it necessary. Portions of it have already appeared from time to time in this magazine, by which our readers have been somewhat informed of its scope and object. Yet the articles published fail to convey any just idea of the adaptation of the book to the needs of those engaged in the work of practical instruction. Certain important psychological considerations of a general nature were brought forward in a way to illustrate their grave significance, but little, however, was said of their bearing on the exigencies of school-work. In the volume these expositions are recast and thrown into such a shape that their applications and bearings are brought out in their full force. The various current studies in our schools are taken up systematically, with the view of determining their educational power, and how they stand related to the unfolding of the mental faculties. This is a most important portion of the work, one hitherto greatly neglected by educators, and the conclusions of which require to be sharply brought out and vigorously enforced. The waste of exertion on worthless objects of study in our schools is something frightful —objects of trifling worth alike in the information they give and in the narrow and imperfect mental discipline they afford. In regard to the study of languages especially, Professor Bain's views are entitled to the most serious attention. The study of language, its critical and careful study, Professor Bain of course recognizes to be of the first importance; but, at the same time, he maintains that the educating power of language is enormously over-estimated. That which is but a preliminary use of tools, indispensable in itself, but utterly subordinate to the larger objects beyond, to which it is but a means and a stepping-stone, has been exalted into the great end, and almost the whole time of education is thus wasted upon initial acquisitions. Professor Bain denies that the study of language, however extended, can educate in any real or adequate sense. After considering this subject, and laying down the principles that should guide its study, and the practice of lingual exercises, he passes, in Chapter X., to the formal consideration of the value of the classics. With this gigantic superstition he makes no terms. The pretexts for its continued ascendancy are successively and effectually exploded. Without denying that some small benefit may of course arise from the study of dead languages, as hitherto and commonly pursued, he demonstrates the utter futility of the several claims put forward in their behalf, and shows how, by standing in the way of modern studies, the classics are a fatal hindrance to that broad and thorough mental discipline which can only be acquired by a larger exercise of the mind in scientific methods, and upon the knowledge of actual things.

An important phase of the work is the treatment of what Professor Bain calls the logical or analytical problem of education. It involves the question of the sequence of

subjects in the various schemes of study, both in relation to the order of the unfolding faculties and with reference to the logical dependence of the subjects themselves. The art of teaching, its various methods, and the principles that should guide them, involving a discussion of the philosophy of object-lessons, are prominently dealt with. Moral education receives passing attention, and Professor Bain suggests various changes which the present system must sooner or later undergo, in a chapter on the higher studies in the curriculum of the future. The author says: "The general strain of the work is a war not so much against error as against confusion. The methods of education have already made much progress, and it were vain to look forward to some single discovery that could change our whole system. Yet I believe that improvements remain to be effected. I take every opportunity of urging that the division of labor in the shape of disjoining incongruous exercises is a chief requisite in any attempt to remodel the teaching art."

We recommend this book emphatically to all teachers, parents, superintendents, and school trustees, who have any serious interest in the improvement of education, and can prize efficient and intelligent help in carrying on their work.

Demonology and Devil-Lore. By Daniel Moncure Conway, M. A. With numerous Illustrations. New York: Henry Holt & Co. 1879. 2 vols. Pp. 444 and 484. Price, $7.

Mr. Conway's studies in demonology were begun many years ago, and in 1859 he published in the series known as "Tracts for To-day" (Cincinnati) an essay entitled "Natural History of the Devil." The very title of that tract was evidence that its author had in his hand the one clew which could conduct him surely through the mazes of the weird and fantastic demon-world. Monstrous and unearthly as the forms of that strange world may appear, they were every one the product of the normal operations of man's mind, as modified by its internal and external conditions, and they can be explained and understood only by tracing them to that source—in other words, by developing their *natural history*. But twenty years ago the idea that demons and devils have a natural history was not so obvious a one as it is to-day; and our author, in giving that title to his essay, approved himself to be a bold and original thinker. Nevertheless, as he confesses in the preface to the work before us, he had then no adequate conception of the vastness of the domain which he attempted to survey. But reading and observation in foreign countries have since given him at once larger and clearer views of that phantasmal world of which, as a denizen of the North American Continent, he had only heard a rumor, so to speak. True, being a native of Virginia, and bred on a plantation, Mr. Conway enjoyed the advantage of observing the phases of demonism in the negro mind; but, for all that, it was only after he had visited in Europe the haunts of the ancient chimeras, goblins, and demons, and made himself familiar with the traditions current among the lower orders of the population, that he could realize the all-pervading force of this superstition.

In the present work Mr. Conway sets forth the results of his protracted researches. The amount of material he has accumulated is enormous, and yet he has by no means exhausted the subject. He aptly likens his effort to "Thor's attempt to drink up a small spring, and his failure because it was *fed by the ocean*." It would be labor in vain for any one man to attempt a full account of the world of demons and devils—a world as diversified and as vast as the physical world around us—and our author has wisely restricted himself to giving illustrations of its leading typical forms. Like another Linné he groups in genera and species, so to speak, these creatures of phantasy, and thus out of direst confusion evolves order and system. Hence his work is valuable, both as a repertory of out-of-the-way information and as an essay in psychological analysis.

It is impossible to give within the limits of a notice like this even an outline of the author's argument, and therefore we will simply call attention to a few of the noteworthy points developed in the work. And first we find a distinction drawn between "demon" and "devil." Demons are beings whose harmfulness is not gratuitous,

but incidental to their own gratifications; a devil loves evil for its own sake. Sometimes a god belonging to a conquered tribe is degraded to the rank of a demon in the mythology of the conquerors. Again, there are demons (or, as the case may be, devils) created by pure accident! "Belial" is an instance of this, being an erroneous personification of "godlessness." The author's remarks on demonism in India are *à propos:* "The Hindoos have covered their land with temples to propitiate and deprecate the demons, and to invoke the deities against . . . drought and famine. Had they concluded that famine was the result of inexactly quartered sun-dials, the land would have been covered with perfect sun-dials; but the famine would have been more destructive, because of the increasing withdrawal of mind and energy from the true cause, and its implied answer. But how much wiser are we of Christendom than the Hindoos? They have adapted their country perfectly for propitiation of famine-demons that do not exist, *at a cost which would long ago have rendered them secure from the famine forces that do exist.* We have similarly covered Christendom, . . . while around our churches, chapels, cathedrals, are the actually existent seething hells of pauperism, shame, and crime." Demonism still subsists among the most enlightened nations, backed by the sternest sanctions it is possible to conceive. "A story is told of a man wandering on a dark night over Dartmoor, whose feet slipped over the edge of a pit. He caught the branch of a tree suspended over the terrible chasm, but, unable to regain the ground, shrieked for help. None came, though he cried out till his voice was gone; and there he remained dangling in agony until the gray light revealed that his feet were only a few inches from the solid ground! Such are the chief demons that bind men till cock-crow. Such are the apprehensions that waste also the moral and intellectual strength of man, and murder his peace *as he regards the necessary science of his time to be cutting some frail tenure sustaining him over a bottomless pit, instead of a release from real terror to the solid ground.*"

The passages we have quoted will give an idea of our author's style and point of view. There is hardly a page of the work which does not contain sentences full of epigrammatic force. Speaking, for instance, of the divers forms ascribed to the devil, Mr. Conway says that "the whites painted him black, and the blacks, *with much more reason*, painted him white."

Paradoxical Philosophy: A Sequel to "The Unseen Universe." London and New York: Macmillan & Co. 1878. Pp. 235. Price, $1.75.

The readers of "The Unseen Universe" will find in the present volume, which is by the same authors, a further discussion of the question of a future state. The work purports to report the proceedings of an imaginary "paradoxical society" at one of its anniversary meetings, and the conflicting views of many different schools of thought upon this subject are set forth with considerable force, and in a way that will interest the most listless reader. The whole subject is treated in the light of modern science; and, though the problem is not brought one hair's breadth nearer to a solution by the clash of arguments, new points of view are at least indicated, new proofs suggested, new difficulties shown to lie in the way of accepting whether the materialistic or the idealistic philosophy. But no less hopeless appears to be the attempt to effect a reconciliation between these two; and the ancient enigma, "Whither are we going?" still remains.

How to be plump, or Talks on Physiological Feeding. By T. C. Duncan, M. D. Chicago: Duncan Brothers. 1878. Pp. 60. Price, 50 cents.

The doctor who writes this book had the good fortune, several years ago, to be employed in the family of an oyster-dealer, and, though it is not stated that oysters were at the time a "legal tender" in Chicago, they appear to have suddenly become a rather large element in our author's bill of fare, since he often ate them when he did not want them, "rather than let them spoil." "Other food" was taken "after or with the oysters"; and whether absence of the harassing cares of a large practice can be counted in or not, certain it is that the doctor, oddly enough, soon found himself grow-

ing stout. "The quieting effects of a few pounds of fat" gave him a "clew to much of the restless activity of Americans"; this led to "much thought" during the next ten years on the subject of "physiological feeding," and, as one of the results, we have the present book. All there is of value in its sixty pages could be better said in as many lines, and they would then contain nothing beyond the merest commonplaces of physiology.

What is the Bible? By J. T. Sunderland. New York: Putnam's Sons. 1878. Pp. 189. $1.

The object of the author in composing this book was to help readers of the Bible to be intelligent readers, not only in the small and meager sense of knowing by heart a multitude of texts, but also in the larger and more worthy way of understanding that book as a whole—whence it came, how it came, what it is, and what relation it bears to other sacred books of the race. The Bible is treated with a reverent spirit by Mr. Sunderland, but that reverence does not prevent him from discerning and pointing out its blemishes. He compares the book to a gold mine, rich indeed in the precious metal, but still a *mine*. There are fools who insist that the whole "output" of this mine is pure gold; no less is the folly of others who, because they see earth and quartz mixed with the gold, declare that the mine contains no gold. "The part of rational men and women," says the author, "surely is to delve earnestly in the mine, casting out, without hesitation, what plainly is not gold, but saving and treasuring up what clearly is gold."

How to parse. By Rev. E. A. Abbott, D. D. Boston: Roberts Brothers. 1878. Pp. 343. $1.

The title of this book is not a very attractive one, and will repel, we fancy, rather than win readers. "Parsing" has fallen into disrepute, and few persons will care to know how it should be performed. But if, overlooking the title, we examine the book, it will be found to contain a great deal of valuable information. What is more, it will serve to give the student an insight into the scientific principles of English grammar.

The Natural History of the Agricultural Ant of Texas. By Henry Christopher McCook. Philadelphia: The author (Academy of Natural Sciences). 1879. Pp. 310, with 24 Lithographic Plates. $4.

A more instructive and entertaining matter of study than the ant tribe it would not be easy to find in the whole animal kingdom outside of man; and, of all the ants, certainly none are more worthy of our attention than the species described in Mr. McCook's present work. A naturalist resident in Texas, the late Dr. Gideon Lincecum, had at sundry times between 1861 and the period of his death, some five or six years ago, contributed to the proceedings of various learned societies notes on the habits of the agricultural ant, but his observations, as we learn from Mr. McCook, were discredited by not a few entomological writers. It was the author's good fortune to confirm in almost every particular the results of the Texas naturalist, and to add to them a multitude of fresh observatious of his own. We therefore heartily welcome the volume, not only on account of the information it contains touching the agricultural ant, but also because it is a triumphant vindication of one of the most ingenious of American naturalists. Mr. McCook, in successive chapters, treats of the surface architecture and work of the agricultural ants, their harvesting habits, their subterranean architecture, their modes of mining, their food and feeding, their "toilet, sleeping, and funeral habits," their social and (if the term be allowable) their political relations, their migrations and movements, their wars; and, finally, he gives a detailed description of their anatomy.

House Air the Cause and Promoter of Disease. By Frank Donaldson, M. D. Baltimore: Innes & Co. print. 1878. Pp. 23.

The author insists on the necessity of frequently renewing the air of inhabited rooms. To the objection that fuel is too costly, and people can not afford to let in the cold air, he replies: "True, more fuel must be consumed. But is not the additional expense a small matter compared with the healthfulness resulting from it? *Fresh air is better worth paying for than even food: it is more essential to health.*"

Wanderings in South America, the North-west of the United States, and the Antilles, in the Years 1812, 1816, 1820, and 1824, with Original Instructions for the Perfect Preservation of Birds, etc., for Cabinets of Natural History. By Charles Waterton, Esq. New edition. Edited, with Biographical Introduction and Explanatory Index, by the Rev. J. G. Wood, with One Hundred Illustrations. London and New York: Macmillan & Co. 1879. Pp. 520. Price, $6.50.

This elegant volume opens with an interesting biographical sketch of the distinguished traveler, whose "Wanderings" has long been the delight of all lovers of natural history. From this sketch we learn that Charles Waterton was born in 1782, in Yorkshire, England. He was descended from a long line of distinguished ancestors, and in early boyhood began to develop that love of nature, power of observation, and originality of character for which he was afterward so celebrated. When ten years old he was sent away to school, and, although the first journey described in his book did not commence till twenty years later, his "wanderings" may be said to have begun at this time. In spite of the stern discipline to which he was subjected, his activity, enterprise, and love of adventure, led him into all sorts of scrapes, from which, however, he generally contrived to escape without serious harm. Such was his attempt to ride a cow, over whose horns he was quickly pitched; at another time he undertook a sail on the horse-pond in a wash-tub, with the usual fate of such daring navigators. Running away from school to go birds'-nesting, and throwing his pursuers off the track by hiding under the litter in a pig-sty, was another characteristic performance.

At fourteen he was transferred to a higher school, where, ranking among the foremost as a scholar, he also found peculiar opportunities for indulging his love of fun and freedom. His teachers early perceiving the bent of his disposition, were sagacious enough to give it fair play, by permitting him to use a portion of his time in carrying on a war of extermination against the rats that infested the place in enormous numbers. His success with these led to an extension of hostilities to the foxes, polecats, and rooks, that were also numerous in the neighborhood; he likewise held the post of organ-blower and foot-ball maker to the "entire satisfaction of the public." At eighteen he left school, remained a year at home, and then took a trip to Spain, where he learned the Spanish language. While visiting relatives in the city of Malaga, he suddenly found himself a prisoner, owing to an outbreak of the plague, which led to measures of rigid quarantine. He took the disease, but fortunately, owing to his simple mode of life and strong constitution, recovered from the attack. Fourteen thousand people perished in the city during that epidemic. Though the port was closed, and all avenues of egress carefully guarded, he succeeded in escaping from the city in time to avoid a second epidemic in the following year, which carried off thirty thousand more of the city's population. Returning to England, he spent some time there in recovering his shattered health, and then started for Demerara, in South America, to take charge of an estate belonging to his family. There he remained for eight years, when, owing to the death of relatives, the property passed into other hands. He now began his famous travels, setting out on his first journey from the town of Stabroek "to travel through the wilds of Demerara and Essequibo, a part of *ci-devant* Dutch Guiana, in South America." "The chief objects in view," he says, "were to collect a quantity of the strongest wourali poison; and to reach the inland frontier fort of Portuguese Guiana." With this start, which was made in April, 1812, the record of Waterton's observations and experiences known as the "Wanderings" begins.

The special objects of this journey were both attained, and a large amount of interesting information on other matters also gathered, but fatigue and exposure had told on the health of the "wanderer," and he found it necessary to return to England, where he remained for the next three years. In the spring of 1816, his health now being fully restored, he again started for South America, landing first at Pernambuco, and sailing thence after a brief stay for Cayenne in French Guiana. The forests of Demerara were, however, his objective point, and without delay he plunged into their wilds a second time, staying several months, and

giving particular attention to the fauna of the country, taking back with him to England a fine collection of birds. In February, 1820, he sailed a third time for Demerara, and, continuing his explorations for a season, returned to England at the end of a year with a larger number of specimens than he had before been able to obtain. But this time a stinging disappointment awaited his arrival. Although his specimens were intended solely for his own museum, and were none of them for sale, impudent and over-zealous custom-house officials gave no end of trouble when he landed by detaining his cases of material, and subsequently exacting heavy duties as a condition of their release. Appeal to the Government did no good, and, smarting under a sense of the outrage, he retired to his home in Yorkshire, resolved not to expose himself to similar annoyance and insult again. Three years later, however, he started on his fourth and last journey, described in the "Wanderings," this time going first to New York, and, after a short trip in the United States, returning by the way of the British West Indies to Demerara. After a stay of a few months, mostly spent in further explorations, he resumed his homeward voyage, reaching England early in 1825.

Mr. Waterton was a keen observer, and in the regions which he visited permitted little in the line of natural history to escape him. The topography of the country, its plants and animals, and the character and habits of its human inhabitants, all received attention; and though at first many of his descriptions were met with incredulity and some of them even with derision, fifty years have served to confirm their accuracy in nearly every particular, and to show that, as an enthusiastic and painstaking investigator, Mr. Waterton had few equals and no superiors. Added to this, the story is simply and most charmingly told, an abundant sprinkling of quiet humor and occasional vivid descriptions of exciting adventures serving to enliven and give variety to the narrative. The "Wanderings" close with a chapter on taxidermy, in which the author attained remarkable proficiency, especially in the mounting of birds. He introduced many improvements in the art, and offers numerous valuable hints for those interested in the preservation of natural history specimens.

Besides the biography, which occupies the first five chapters of the book, Mr. Wood has supplied a full "Explanatory Index," which contains a large amount of valuable information regarding the animals and plants mentioned in the "Wanderings." Many of these were described by Mr. Waterton under their local names, which, for scientific purposes, were of little use. In type, paper, illustrations, and binding, the publisher has left nothing to be desired.

The American Journal of Otology. Edited by Clarence J. Blake, M. D. Quarterly. Vol. I., No. 1. New York: William Wood & Co. Pp. 80. Price, $3 per year.

As the editor of this new journal remarks in his introductory note, "the past ten years have seen a remarkable increase of interest in the study of the laws which govern the production and propagation of sonorous vibrations, and correspondingly in the structure, functions, and diseases" of the ear. Hence the "Journal of Otology" is a welcome addition to the list of American medical and scientific periodicals. The editor is assisted by a very strong staff, viz., Professor A. M. Mayer, Dr. Albert H. Buck, Dr. C. H. Burnett, Dr. J. Orne Green, and Dr. H. N. Spencer. The articles in the present number are: "Graphic and Photographic Illustrations of Sound-Waves," by the editor; "Growth of Aspergillus in the Living Human Ear," by Dr. C. H. Burnett; "Syphilitic Affections of the Ear," by Dr. A. H. Buck; "Use of Calcium Sulphide in the Treatment of Inflammations of the External Auditory Meatus," by Dr. S. Sexton; Book Notices; and Reviews.

Industrial Education. By Professor Alexander Hogg. Galveston, Texas: "News" Print. 1879. Pp. 52.

The author, who is a Professor of Mathematics in the Agricultural and Mechanical College of Texas, in his first chapter sketches a course of studies suitable for an institution of that kind; in his second and third chapters he describes the present state of the Texas Agricultural College, and points out some of its more pressing needs.

Air and Moisture on Shipboard: A Fragment of Applied Physiology. By Th. J. Turner, A. M., M. D., Ph. D. Pp. 15.

The notion is prevalent that life on shipboard is especially healthy, and the doctors are constantly sending patients to sea for the benefits they are there expected to obtain. That the belief is an error, and the practice a mistaken one, this pamphlet abundantly proves. Indeed, according to the statistics which the author gives, few unhealthier places can be found than one of our modern naval vessels when in active service. This appears to be due mainly to foul air and a superabundance of moisture, both of which, as the writer points out, can be easily avoided by the substitution of a few simple sanitary measures for the stupid routine that now commonly controls in the management of ships.

On the Genealogy of Plants (20 pp.), and On the Natural Succession of the Dicotyledons (11 pp.). By Lester F. Ward, A. M. Reprinted from the "American Naturalist."

The first of these pamphlets begins with an indictment of the present system of botanical classification, which the author regards as altogether out of harmony with the facts of organic evolution as developed during the last twenty years; and as requiring the introduction of certain important modifications, some of which he outlines. The second pamphlet is a discussion of the classification of the dicotyledons, from the same point of view, namely, that of the evolutionist.

Notes on Cladocera. By Edward A. Birge, Ph. D., Instructor in the University of Wisconsin. Pp. 33, with Two Plates.

This is a technical description of several new species and one new genus of minute fresh-water crustaceans found by the author at different localities in this country. The water-flea (*Daphnia*) is a familiar example of the group.

The Air we breathe. New York: S. Hamilton's Sons Print. Pp. 17.

We have here a report of a Citizens' Committee on the nuisances of New York City, or rather on its "stench-factories"—slaughter-houses, fat-rendering establishments, etc.

The Soul and the Resurrection. By J. H. Kellogg, M. D. Battle Creek, Michigan: "Review and Herald" Publishing Association. 1879. Pp. 224. Price, 75 cents.

Here is another attempt at establishing harmony between science and the Bible. The author looks on science and the Bible as "complementary revelations," though the latter he regards as of by far the greater importance. Still, he does not by any means require that science should surrender at discretion to its "superior." On the contrary, indeed, not a few of our author's propositions seem to us to imply that the whole body of "revealed truth" is subject to revision and correction by science. The orthodox reader will be shocked when he finds the harmonizer plainly declaring that "the study of mind is now a subject for the physiologist," and that "the soul is neither conscious nor immortal."

Principal Characters of the American Jurassic Dinosaurs. With Plates. Pp. 6. A New Order of Extinct Reptiles. By Professor O. C. Marsh. With Plates. Pp. 8.

These papers are reprinted from the "American Journal of Science." We gave an abstract of each of them on their appearance in our contemporary.

The Principles of Breeding. By Professor W. H. Brewer. Pp. 20.

Professor Brewer is an authority on the subject which he has treated in this too brief paper. It is reprinted from the reprint of the Secretary of the New Hampshire Board of Agriculture.

Notes on the Aphididæ of the United States. By C. V. Riley and J. Monell. With Plates from Hayden's Survey. Pp. 32.

In this paper are set forth many interesting biological facts relating to the gall-making *Pemphiginæ*. Such facts possess a peculiar importance just at present, on account of the close relationship between these insects and the *Phylloxera* of the grapevine.

Art Anatomy. By Dr. A. J. Howe. Pp. 23.

The painter and sculptor will find many a valuable hint in this unpretending little essay.

PUBLICATIONS RECEIVED.

The Speaking Telephone, Electric Light, and other Recent Electrical Inventions. By George B. Prescott. With Illustrations. New York: D. Appleton & Co. 1879. Pp. 616. $4.

Report of the British Association for the Advancement of Science (1877). London: John Murray. Pp. 679.

Die Entwickelnng des Menschengeschlechtes. Von Dr. Adelrich Steinach. Basel: Benno Schwabe; New York: Schlaepfer, 109 Allen St. 1878. Pp. 687. $2.50.

The Currency Question from a Southern Point of View. By R. W. Hughes. New York: Putnam's Sons. 1879. Pp. 222. $1.25.

Testing of Water-Wheels and Machinery. By James Emerson. Springfield, Massachusetts: Weaver, Shipman & Co. print. 1878. Pp. 216. $1.50.

Naval Hygiene; Human Health. By Joseph Wilson, M. D. With Colored Lithographs. Philadelphia: Lindsay & Blakiston. 1879. Pp. 274. $3.

Report of the United States Entomological Commission (1877). With Plates. Washington: Government Printing-Office. 1878. Pp. 771.

The Young Scientist. Vol. I. New York: Industrial Publication Co. 1878. Pp. 164.

Reading as a Fine Art. By Ernest Legouvé. Boston: Roberts Bros. 1879. Pp. 97. 50 cents.

Report of the Observations of the Total Solar Eclipse (1878) made at Fort Worth. Leonard Waldo, Editor. Cambridge: Press of John Wilson & Son. 1879. Pp. 60.

Habit and Intelligence. By John Joseph Murphy. Revised edition. London and New York: Macmillan. Pp. 621. $5.

After Death what? By Rev. W. H. Platt. Revised and enlarged. San Francisco: Roman & Co. Pp. 209. $1.25.

Health, and how to promote it. By Richard McSherry, M. D. New York: D. Appleton & Co. Pp. 196. $1 25.

Archivos do Museu nacional do Rio de Janeiro. With Plates. Rio de Janeiro: Typographia do imperial instituto artistico. 1878. Vol. II., pp. 175; Vol. III., pp. 50.

Proceedings of the New England Cotton Manufacturers' Association. Boston: A. Williams & Co. print. Pp. 79.

Voussoir Arches. By William Cain, C. E. New York: Van Nostrand. 1879. Pp. 196. 50 cents.

Journal of Physiology. Michael Foster, M. D., Editor. With Plates. London and New York: Macmillan. Vol. I, No. 6. Pp. 70. $5.25 per year.

American Statistical Review. Quarterly. New York: D. Appleton & Co. Vol. I., Part 1. Pp. 120. $5 per year.

A Rational View of the Bible. By Newton M. Mann. Rochester, New York: Charles Mann print. 1879. Pp. 136.

The Horse and his Diseases. By B. J. Kendall, M. D. Enosburg Falls, Vermont: Published by the Author. Pp. 89. 25 cents.

Proceedings of the American Chemical Society. New York: Baker & Godwin print. 1879. Vol. II., No. 4. Pp. 24.

Chemical Examinations of Sewer Air. By Professor William Ripley Nichols. Boston: Rockwell & Churchill print. 1879. Pp. 16.

The Wisconsin Tornadoes of May 23, 1878. By W. W. Daniels. With Plates. Pp. 41.

Philosophy of Christianity. By Pliny E. Chase. Pp. 31.

The Hydatiform Mole. By J. W. Underhill, M. D. Cincinnati: "Lancet" print. 1879. Pp. 20.

The Female Generative Organs in their Medico-Legal Relations. By the same Author. New York: W. Wood & Co. Pp. 20.

Flora of Richmond County, New York. By Arthur Hollick and N. L. Britton. Staten Island: Published by the Authors. 1879. Pp. 36. 50 cents.

Annual Report of the Schools of the Province of Ontario (1877). Toronto: Hunter, Rose & Co. print. Pp. 260.

The Devonian Brachiopoda of Pará, Brazil. By Richard Rathbun. From "Proceedings of the Boston Society of Natural History." Pp. 39.

Sketch of New Zealand. By I. C. Russell. From "American Naturalist." Pp. 13.

Beneficial Influence of Plants. By J. M. Anders, M. D. From "American Naturalist." Pp. 15.

Relation of the National Government to Science. Speech of Hon. J. A. Garfield. Washington. 1879. Pp. 7.

Industrial Arbitration and Conciliation. By Joseph D. Weeks. Pittsburgh, Pennsylvania: Anderson & Son print. Pp. 16.

The Triassic Formation of New Jersey and the Connecticut Valley. By I. C. Russell. New York: Gregory Bros. print. Pp. 35.

The Animal, Vegetable, and Mineral Kingdoms. By Mrs. N. B. Walker. New York: Wilbur & Hastings print. 1879. Pp. 18.

Report of the Freedmen's Aid Society of the M. E. Church (1878). Cincinnati: Book Concern. Pp. 64.

The Cobden Club. Letter by S. S. Boyce. Pp. 5.

Nature and Possibilities of Social Science. By Pierce Burton. Aurora, Illinois: "Herald" print. Pp. 8.

Common Sense on the Salt Question. By Henry A. Mott, Jr. New York: Nesbitt & Co. print. Pp. 11.

Natural Method in Language. By John E. Earp. Indianapolis: Douglass & Carlon print. 1879. Pp. 8.

POPULAR MISCELLANY.

The History of Map-making.—The President of the American Geographical Society, Judge Daly, in an address on the history of map-making previous to the time of Mercator, expressed his belief that the cartographic art is as old as, or even older than, the invention of the alphabet. The earliest map or topographical design extant, so far as we know, is the ground-plan of the town of Susa (in the Bible Shushan). This is assumed to date from the seventh century before our era. According to Strabo, Anaximander (born 612 B. C.) first represented the world in a map. The earth at that time was held to be a flat, circular plain entirely surrounded by the ocean-river. Greece was in the center of the plain. The great central sea of the inhabited region was the Mediterranean. The farthest point known on the west was the Pillars of Hercules

(strait of Gibraltar). Parmenides (born 513 B. C.) is said by Diogenes Laertius to have been the first to assert the sphericity of the earth, and that it is situate in the center of the universe. Strabo credits Parmenides also with having been the first to divide the globe into five zones, or *climates* as they were called. Passing lightly over the twelve centuries between Ptolemy and the awakening of maritime enterprise which led to the discovery of America, Judge Daly spoke of the large map of the world constructed in Venice in 1457 by Fra Mauro. This map was painted on the wall of a convent in Venice, and it is remarkable not only for the extent of the geographical information it embodies, but for the artistic skill with which it is executed. But even the maps constructed after the time of Columbus and Magelhaens in their delineation of the outline of countries were very defective, and especially in respect to the American Continent. The accessories to geographical knowledge had become so vast, that the work of giving the whole surface of the earth as far as known, in all its details, with any approximation to correctness, was not accomplished till Mercator produced his great map of the world in 1569. In this map he introduced what has ever since been known as Mercator's projection, which not only gives the world in one view, but by a very curious and simple contrivance showed the most effectual way for a vessel to sail on a straight line over a curved surface, and thereby solved what was before one of the most difficult problems in navigation.

Fiords of Glacial Origin on Long Island.—In a paper by Mr. E. Lewis, Jr., read before the Natural History Section of the Long Island Historical Society, some account is given of the fiords which occur on the north side of Long Island, bordering Long Island Sound. In a distance of fifty miles eight of large size occur, penetrating the island to near its center. There are several small ones, remains evidently of large valleys that have been shortened by wearing away of the banks at the sound-shore. The waters of the sound extend into the large valleys from two to six miles, forming safe and beautiful harbors. Fiords, common on rocky coasts, like those of Maine or Greenland, are not frequent in the drift, but those described are singularly perfect in form. They are simply long, deep valleys, from half a mile to a mile broad, their source being in the hill region of the central part of the island. The depth of water in the deep portions of the fiords is from ten to thirty feet, but in a few places where the tidal currents are rapid depths of forty and even fifty feet are found. It is quite certain that sediment is slowly accumulating in the harbors, and is already of considerable thickness. Piles have been driven in one instance through forty feet of soft ooze, and meadows now occupy the upper portions of the valleys. The banks vary in elevation. The general elevation of the country throughout the region may be 150 feet above tide, but it is very undulating, being traversed by a great number of small lateral valleys, which open into the great fiords, chiefly on their easterly side. On the west side of Hempstead Harbor (Roslyn) the bank is 250 feet high, and at one point known as "Beacon Hill" attains an elevation of 307 feet. If to this height we add the depth of water and of sediment in the harbor, it will show that the extreme depth of the valley was not less than 350 feet when its bottom was swept by a glacial stream. There is reason to believe that in several instances these fiord valleys were once continuous southward to the ocean, and the site of glacial rivers flowing in that direction. They probably became filled with *débris* from the melting glacier, as it finally yielded to a change of climate. From that time the discharge of glacial water was northward through what is now Long Island Sound. The conclusion is, that nearly all the fiords in question are not eroded valleys, but are what remains of river valleys, maintained as such, while the deposit of drift went on. The lateral, or small valleys, referred to were mainly produced by erosion, but why they occur so largely on the easterly side of the great fiords is not explained.

Rainfall and Sun-spots.—The relation between rainfall and sun-spots is a subject which has been discussed with no little heat for a few years past. Of speculation and theory there is more than enough, and it is

time to collect and note the facts. Here is a table showing the readings of the Nilometer for thirteen years, from which it is clear that the river Nile, during that time at least, does not confirm the rule, "Maximum spots, maximum rainfall":

Years.	Depth of the Nile.		
1866	28¼	feet	minimum spots.
1867	24½	"	minimum spots.
1868	19	"	
1869	29¼	"	
1870	25½	"	
1871	23¾	"	
1872	25½	"	maximum spots.
1873	20	"	
1874	29	"	
1875	24	"	
1876	25	"	
1877	18	"	minimum spots.
1878	30	"	

The Vertebral Articulations in Birds.—Professor Marsh, in the "American Journal of Science and Arts" for April, essays an explanation of the peculiar saddle-shaped articulation seen in the vertebræ of birds. Between *Ichthyornis* and *Hesperornis*, two birds with teeth from the Cretaceous, there is the widest conceivable difference as regards this part of the skeleton, in *Hesperornis* the ends of the centrum being saddle-shaped, as in ordinary birds, while in *Ichthyornis* the articulation of the centrum is cup-shaped. But in the third cervical vertebra of *Ichthyornis*, Professor Marsh catches nature in the act, as it were, of forming a new type, by modifying one form of vertebra into another. Following this hint, the connection between these widely divergent types of structure soon becomes apparent, and the development of the modern form of avian vertebra from the fish-like biconcave form finds a solution. In the anterior articulation of this vertebra of *Ichthyornis* the surface looks downward and forward, being inclined at an angle of nearly 60° with the axis of the centrum. In vertical section it is moderately convex, while transversely it is strongly concave, thus presenting a near approach to the saddle-like articulation. None of the other vertebræ of *Ichthyornis* possesses this character. "This highly specialized feature," remarks Professor Marsh, "occurs at the first bend of the neck, and greatly facilitates motion in a vertical plane. If, now, we consider for a moment that the dominant motion in the neck of a modern bird is in a vertical plane, we see at once that anything that tends to facilitate this motion would be an advantage, and that the motion itself would tend directly to produce this modification. With biconcave vertebræ, the flexure in any direction is dependent on the elasticity of the fibrous tissue that connects them, as the edges of the cup do not slide over each other. An increasing movement in the neck of *Ichthyornis* in a vertical plane would tend to deflect the upper and lower margins of the circular cup, and to produce a vertical constriction, and at the same time to leave the lateral margins projecting; and this is precisely what we have in the third vertebra. This modification of the vertebræ would natu.ally appear first where the neck had most motion, viz., in the anterior cervicals, and gradually would be extended down the neck; and, on to the sacrum, if the same flexure were continued. Behind the axis, or where the vertical motion prevails, we find in modern birds no exception to the saddle articulation in the whole cervical series. In the dorsal vertebræ, this cause would be less efficient, since the ribs and neural spines tend to restrict vertical motion, and hence to arrest this modification. This region, then, as might be expected, offers strong confirmatory evidence of the correctness of the above explanation; for here occur, among modern birds, the only true exceptions known in the presacral series to the characteristic saddle-shaped articulation."

Professor Tyndall on Sound.—Professor Tyndall is this season giving a course of lectures on sound at the London Royal Institution. In the first lecture he illustrated by many experiments the action of sound-waves, and explained the mechanism of the ear. In treating of the velocity of sound, he said that at the temperature of 32° Fahr. air conveys sound-waves 1,090 feet per second, but that this rate varies with every variation of the temperature. It is well known that, when a mechanically striking bell is placed under a receiver exhausted of air, no sound is heard. Professor Tyndall showed by experiments that when a little air, about one fourth, is admitted into the receiver, the sound is feeble only; but on introducing a little hydrogen, the sound was again stilled. This fact was known to

Sir John Herschel, and he gave the explanation that hydrogen *breaks the continuity of the medium.* But this is not the true explanation. Professor Stokes, paying attention to the fact that when a tuning-fork is struck and held in air it gives out but little sound, investigated the subject, and arrived at the conclusion that air is so mobile that it runs around the tuning-fork without being thrown into waves. Check this "running round" by holding a card at one side of the fork, and the sound is augmented. Now, hydrogen is more mobile still than air, and hence the probable explanation of the bell not sounding in it is, that the hydrogen "runs round" so readily that it is not thrown into waves. Alluding to Newton's attempt to reconcile his theoretical calculation of 916 feet per second with the experimental results of 1,090 feet per second as the velocity of sound, Professor Tyndall said that the philosopher had forgotten to take into account the heat developed by the sound-wave in its own path. By the aid of the thermopile and galvanometer arrangement, the lecturer showed that a very gentle and small compression of air does produce heat. Several experiments to show the passage of sound through wood, water, and other bodies were made in the concluding part of the lecture. In one of these experiments music played in the cellars of the Institution was made audible by a connecting wooden rod rising into the lecture-hall, a common wooden tray being alternately held on the top of the rod and removed again. The rod itself had not surface enough to give vibrations which can be heard, but the larger surface of the tray gave the "magic music."

An ingenious and very simple method of measuring the velocity of sound in air and other gases is described by M. Bichat, in the "Journal de Physique." A tube about ten metres long, made of tin plate, is bent so that its extremities *A* and *B* are near together. The end *A* is closed by an India-rubber membrane; the end *B* carries a cork with a glass tube through it, which communicates, by means of an India-rubber tube, with a Marey's manometric capsule. These capsules are arranged in front of a blackened cylinder, so that the extremities of their levers rest upon the same generating line. Close by these a tuning-fork, making one hundred vibrations per second, is placed, and inscribes its vibrations side by side with those of the manometric capsules. The experiment being so arranged, a slight shock is given by the hand to the membrane *A*, the blackened cylinder meantime being turned. The capsules register the point of departure and the point of arrival, while the tuning-fork gives the time. In this way the velocity of sound in air was found by M. Bichat to be 333.3 metres per second. By means of two tin tubes, placed one above the other, we may in a single experiment demonstrate the difference of velocities of sound in air and in hydrogen; but it is difficult, in consequence of diffusion through the India-rubber, to keep the tube full of pure hydrogen.

Recent Exploration of Wyandotte Cave.—Wyandotte Cave, in Crawford County, Indiana, has a total length of twenty-three miles, including all the avenues; it includes many fine halls and domed chambers, the largest of which has a circumference of one thousand feet, and is said to be two hundred and five feet high. The Rev. H. C. Hovey mentions, in "The American Journal of Science," an important discovery made in this cave last April by a party of students from Wabash College. Forcing their way through a low, narrow passage from the locality known as Rugged Pass, the party entered a realm of chaos. "Pits, miry banks, huge rocks, are overhung by galleries of creamy stalactite, vermicular tubes intertwined, frozen cataracts, and all, in short, that Nature could do in her wildest and most fantastic mood." One of the curiosities of this place is a row of stalactites on which a musical chord can be struck or a melody played. What is known as the "Old Cave" was worked by saltpeter miners in 1812, and sundry acts of vandalism have been charged on them which more probably were done by the aborigines. The finest stalacto-stalagmitic column probably in the world is the Pillar of the Constitution in this "Old Cave." It is forty feet high, twenty-five feet in diameter, and it rests on a base three hundred feet in circumference. The weight of this immense mass of alabaster caused the underlying rocks to settle, and this in turn cracked the base, caus-

ing great crevices. At some former time a large segment was cut from the base of this column. Starting from one of these crevices, an excavation was made, cutting a mass from the base having an arc of thirty feet, and making a cavity in the pillar itself ten feet wide, seven feet high, and five feet deep. This excavation has hitherto been regarded as a deliberate attempt of the miners to fell the column, but Mr. Hovey thinks the work must have been done a thousand years ago.

Commercial Products of New Caledonia.—M. Jules Garnier, who has spent three years in New Caledonia investigating its mineral resources, states that all the principal vegetable productions of the tropics grow well on that island, though, with the exception of coffee and tobacco, they are subject to periodical destruction by invasions of grasshoppers. Cotton, moreover, is liable to damage during the rainy season, which, coinciding with the gathering of the crop, destroys the produce. There are several native oil-yielding plants, and the culture of the mulberry and silkworm have been introduced with success. The forests contain many useful timber-trees; but the most active industry is the raising of cattle, in which an active export trade is carried on with Australia. Of other animal products there is nothing of commercial value except the fish, which are abundant and of great variety. The chief source of wealth in the island is, however, its metallic products. It is rich in gold, copper, and nickel, the latter presenting itself in the form of a magnesian hydro-silicate, called by Professor Dana Garnierite. The native inhabitants number thirty-five thousand, and the whites seventeen thousand. The recent insurrection will not interfere with the progress of the colony.

Professor A. Agassiz's Zoological Laboratory.—Professor Alexander Agassiz's zoological laboratory at Newport is admirably contrived to accommodate a small number of workers. It is forty-five by twenty-five feet. The whole of the northern side of the floor, upon which the work-tables and microscope-stands are placed, is supported on brick piers and arches independent of the brick walls of the building. The rest of the floor is supported entirely on the outside walls and on columns on the north side. This gives to the microscopic work the great advantage of complete isolation from all disturbance caused by persons walking over the floor. The material for the laboratory procurable at Newport is abundant. The dredging is fair and not difficult, as the depth in the immediate neighborhood does not exceed twenty to thirty fathoms. The pelagic fauna, however, is the most abundant. During the course of each summer, by the use of the dip-net, representatives of all the more interesting marine forms can be found. The laboratory stands on a point at the entrance of Newport Harbor, past which sweeps the body of water brought by each tide into Narragansett Bay, and carrying with it everything which the prevailing southwesterly wind drives before it. Newport Island and the neighboring shores form the only rocky district in the long stretch of sandy beaches extending southward from Cape Cod—an oasis, as it were, for the abundant development of marine life along its shores.

Making Sound-Vibrations visible.—A very ingenious method of recording articulate vibrations by means of photography has just been invented. The apparatus (says "Galignani's Messenger") consists of a steel mirror capable of oscillations on a diametral axis, to the back of which is attached a lever connecting it with the center of a telephone-disk arranged with an ordinary mouthpiece. Whenever the disk is made to vibrate, the mirror oscillates with it, and a beam of sunlight thrown on the reflector from a heliostat describes lines of light on a suitably prepared screen. If the latter be movable at right angles to those lines of light, and carries a collodion film, the oscillation of the light is recorded on the prepared surface as a more or less complex curve having the peculiarity of the sound-wave which caused each particular motion. Another and simpler phoneidoscope is suggested by a writer in "Nature": it may be made without the aid of any apparatus whatever, by bending the forefinger and thumb of one hand so as to form a circle, and then with the other hand draw-

ing over the aperture a film of soapsuds. By turning the wrist, the angle made with the direction of the light may be readily adjusted; a motion of the elbow alters the distance from the mouth, and the tension of the film can be exactly regulated by moving the thumb and finger. On singing or speaking to the film when in proper tension, beautiful figures appear, which may be reflected direct from the film on a screen. The experiment is extremely curious and interesting.

George Bidder, the "Calculating Boy."—There died lately in England a man of prodigious arithmetical power, whose mental faculties would afford matter for profound research to the psychologist. George Bidder made his mark in early life as a "calculating boy"; but in him one overgrown faculty did not eclipse all the other mental powers, for throughout life (he died aged seventy-two years) he evinced first-rate business ability, and in fact accumulated a large fortune by his own exertions. Nor did his mathematical faculty decline as his other powers matured; to the last he was capable of the same astonishing feats of calculation which made him remarkable as a boy. Instances of his extraordinary powers are given in a letter written by James Elliot, Professor of Mathematics in Queen's College, Liverpool, who was Bidder's fellow student in Edinburgh. Of these we quote two: A person might read to Bidder two series of fifteen figures each, and, without seeing or writing down a single figure, he could multiply the one by the other without error. Once, while he was giving evidence before a Parliamentary committee, counsel on the opposite side interrupted him with, "You might as well profess to tell us how many gallons of water flow through Westminster Bridge in an hour." "I can tell you that too," was the reply, and he gave the number instantaneously.

Certain interesting facts are mentioned with regard to the possession of the same or similar powers by members of Bidder's family. His eldest son, who is a successful barrister, can play two games of chess simultaneously without seeing the board. Like his father, he can multiply fifteen figures by fifteen without seeing them, but by a peculiar process. One of the grandsons showed a very marked degree of mechanical ingenuity. Even the granddaughters possess extraordinary powers of calculation. George Bidder's elder brother, a Unitarian minister, was not remarkable as an arithmetician, but had an extraordinary memory for Bible texts, and could quote almost any text in the Bible, and give chapter and verse. Another brother was an excellent mathematician, and was actuary of a great life-insurance company.

Peruvian Antiquities.—In an article on Peruvian antiquities, published in the "Kansas City Review of Science and Industry," Dr. E. R. Heath gives an interesting account of the vast wealth of ruins with which the land of the Incas is overstrewed. Go where you will in Peru, and relics of the past meet your eye either in ruined walls, watercourses, terraces, or extensive areas covered with broken pottery. Dr. Heath takes as an illustrative instance the Jequetepeque Valley. Here the bottom-lands of the river are from two to three miles in width, with a southern sloping bank, and the northern a perpendicular one nearly eighty feet high. Beside the southern bank, near the point where the river empties into the sea, is an elevated platform, one quarter of a mile square and forty feet high, all of adobe. A wall, fifty feet wide, connects it with another distant a few hundred yards, which is 150 feet high, 200 feet across the top, and 500 feet at the base, and nearly square. This latter structure was built in sections or rooms ten feet square at the base, six feet at the top, and about eight feet high. These rooms were afterward filled with adobes, then plastered on the outside with mud and washed in colors. All the Peruvian mounds of this class have on the north side an incline as a means of access. On the north side of the river, on the top of the bluff, are the ruins of a walled city two miles wide by six miles long. In following the river to the mountains you pass ruin after ruin, one artificial mound (*huaca*) after another. At Tolon, a town at the base of the mountains, the valley is crossed by walls of bowlders and cobble-stones, ten, eight, and six feet high, one foot to eighteen inches wide at the top and two to three feet at the base,

inclosing the ruins of a town one quarter of a mile wide and more than a mile long. At this point the railroad enters the Jequetepeque Valley. For eight miles it crosses a barren sand-plain of more than fifteen miles in length, covered with ruined walls, water-courses, dead algaroba and espino trees, with fragments of pottery and sea-shells, even to nine feet in depth, mixed with the sand. The bases of the mountains have, in a good state of preservation, many thousand feet of an old watercourse, while their sides to the perpendicular parts are lined with terraces. This watercourse, now dry, can be traced for the distance of forty-five miles.

Important Discovery in Entomology.—Mr. Gray, of Albany, has been engaged in the study of our diurnal *Lepidoptera* for many years. He has made the discovery, as published in the "Canadian Entomologist," that our Eastern species of *Liminitis*, four in number, are not distinct. They belong to a single plastic genetic group, of which *arthemis* is the most northern, *proserpina* intermediate between *arthemis* and *ursula*, and the red *disippus* the most southern. He has collected them in vertical altitudes on hills in the Middle States and New England, and has intermediary specimens half bluish and red between the two most strikingly contrasted species of the group *ursula* and *disippus*. This discovery is the most remarkable in the group announced since the recognition of the female form of *diana* by Mr. W. H. Edwards. In general interest it far surpasses that discovery, and we expect will be more generally noticed.

California Climates and Consumption.—The conditions requisite in a health resort for consumptive patients are relative dryness of atmosphere and an agreeable and equable temperature throughout the year. There are in the State of California a number of localities in which these conditions are happily combined, and which afford to the consumptive opportunity for living out-of-doors at all seasons. In the "Alta California Almanac" is published a table setting forth the mean relative humidity, and mean temperature, summer and winter, of the most noted sanitaria in the State, from which we make a few selections. The places which have the least humidity are Atlas Peak and Blakes, the former 1,500 feet above sea-level, and the latter 2,100, and both situated in a mountain-ridge east of Napa Valley. This ridge is thirty miles from the sea, is seldom covered by fog, is beyond the reach of the cold sea-breezes, and is warmer in winter and cooler in summer than the valleys on each side. At Atlas Peak the relative humidity is in summer 39°, in winter 51°—"summer" standing for the "dry season" from May to October, and "winter" for the "wet season" from November to April, inclusive. The mean temperature for January at Atlas Peak is 50° Fahr., and for July 74°. At Blakes the relative humidity for summer is 39°, and for winter 60°; and the mean temperature for January is 45°, for July 73° Fahr. These two localities are only a few miles distant from one another, and are within five or six hours' travel from San Francisco. Other localities are represented in the table as follows:

STATIONS.	RELATIVE HUMIDITY.		MEAN TEMPERATURE.	
	Summer.	Winter.	January.	July.
Camp Apache.	57°	56°	38°	84°
Visalia........	42	72	45	80
Anaheim......	64	60	50	68
Fort Yuma...	58	68	56	97
Los Angeles..	66	64	52	75
Santa Barbara	71	67	53	68
San Diego....	75	69	51	72
San Rafael....	65	83	48	67

Resurvey of Yellowstone Park.—A good summary of the work done by Hayden's Survey of the Territories during the season of 1878 is published in the "Naturalist," from which we learn that the *personnel* of the Survey was divided into four parties: one for the extension of the primary triangulation northward, two for topographical and geological work, and one for photography and special work in geology. All the parties left the Union Pacific Railroad at Point of Rocks and Green River stations about July 25th, and proceeded northward toward the Yellowstone National Park. To the second division was assigned the duty of making an exhaustive survey of the park and its surroundings, and to the third the exploration of the Wind River range and the Snake River country. The primary tri-

angulation was extended over about 12,000 square miles. Materials were collected for a topographical map of the Yellowstone Park, on the scale of one mile to an inch. Its geology was studied minutely. A peak of the Wind River range, named Fremont's Peak, was found to be over 14,000 feet in height above the sea; no trace could be seen of the presence of man on its summit at any time. Three glaciers were discovered on the east side of the Wind River Mountains. The object of again surveying the Yellowstone Park was to bring it under the system of triangulation, which has been very successfully employed in Colorado, and to make the entire work uniform. All the old hot-spring basins were resurveyed and mapped, soundings and temperatures of several thousand hot springs were made, and the action of the geysers carefully studied. Over fifty fine photographic views were obtained of the bowls and other curious ornamental details of the Hot Springs.

The Personal Equation.—One of the principal defects of "our primary mathematical instrument," the human mind itself with its organic apparatus, is very clearly pointed out by W. Mattieu Williams. This defect makes itself apparent in certain astronomical observations, when the observer has to note the moment at which a star appears to touch the wire or wires stretched across the field of a telescope. The old way of doing this was to look at a clock as the star approaches the wire, count the beats of the clock, and then note at which beat or fraction of the beat the transit of the wire occurs. Despite the apparent simplicity of this operation there is no human being whose eye, ear, and internal nervous apparatus of perception and volition are sufficiently perfect to perform it accurately. None of us either sees, hears, or feels instantaneously. The sensation has to be transmitted from the external organ of sense to the nervous center, and the response has to be transmitted outward. These operations involve time. Nor is that all: they require a different length of time for different persons, different constitutions. Thus in the same observatory there may be three assistants, A, B, and C, and they are tested by making a number of corresponding observations. In every case it will be found that A is say a quarter of a second ahead of B, and B half a second ahead of C. What is to be done? If all erred alike—if all observers required just half a second to collect their sensations of sight and hearing, and to bring them to bear upon the same perception, then by setting the clock half a second ahead of the true time, the needed correction would be made. But, failing this, some personal standard of comparison must be taken, and the observers rated to this standard like chronometers. This is done in observatories, and the result is called the "personal equation" of the individual observer. And not only has the personal equation of each observer to be determined on his entrance upon his duties, but it demands periodical revision, for it varies with age and constitutional conditions.

Use of the Balloon in Arctic Exploration.—In a paper read before the London Aëronautical Society, Mr. Brearey, its secretary, advocated the employment of balloons in polar exploration. Referrring to the last English polar expedition, Mr. Brearey said that, instead of a seventy days' journey to accomplish about seventy miles, at a fearful cost of life and suffering, consequent on having to drag over ice hummocks sleds containing provisions, the whole of the stores could have been conveyed over the heads of the explorers, and the men holding the ropes of this floating observatory would have been assisted by the upward tendency of the balloon. The question is, Would the daily consumption of stores compensate the leakage of gas? and its answer is found in Beaumont's history of the balloon as employed in the United States war of the rebellion. He writes that "the balloon when inflated can, unless in very windy weather, be very readily carried. Twenty-five or thirty men lay hold of cords attached to the ring and march along, allowing the machine to rise only sufficiently to clear any obstacle." He had frequently seen it carried thus without the least difficulty. As for the leakage of gas, by the use of proper varnish it might be so checked that at the end of a fortnight the balloon could make an ascent without being replenished. Re-

marks by various members of the Society followed the reading of the paper; they are briefly stated in the "Monthly Journal of Science," and are, on the whole, favorable to Mr. Brearey's views. Mr. Glaisher saw no reason why the balloon should not be made available in arctic exploration, and he hoped that, if there were another expedition, the balloon would be tried and the question settled. It would certainly, if used in connection with a sled, enable the explorers to travel much more rapidly than they can at present. Touching on the use of the balloon as an observatory, he said that, when he was only half a mile over London, he could see Margate and Brighton. This showed how much may be seen from a comparatively small elevation.

A Blood-sucking Squirrel.—Dr. Richard E. Kunze gives in "Science News" an entertaining account of a pair (male and female) of pet gray squirrels, one of which, the male, he detected in the act of sucking the other's blood. Having noticed that the female looked emaciated, and that in moving about she dragged a hind leg, Dr. Kunze made an examination, which resulted in the discovery of a circular hole in this leg directly over the hamstring muscles, extending through the entire thickness of the skin. The edges of this opening, or sore, which was of the diameter of a lead-pencil, looked smooth and blanched. Now, it could not be the result of a puncture or any other wound, because there was present neither inflammation nor discharge. It had the appearance of an artificial issue, was sensitive but not painful. For a time he was puzzled to account for the hole, but at last he caught her companion in the act of sucking her blood. The "vampire" was seen to bury his snout deeply in the fur in the direction of the sore. Soon the female squirrel, which had before been asleep, gave a sharp cry. "My suspicions," writes Dr. Kunze, "were soon confirmed, that he was actually sucking out the very life-substance of his mate. For several days a number of medical friends kept a sharp lookout on Foxie's unnatural conduct. At first we simply drove him away from his mate whenever he was intentionally too near the coveted spot. We now had to beat him off. In proportion as we resorted to such severe measures, Foxie became more cunning, and with an Argus-eye would watch his chance to act unobserved. Finally, he became much bolder in his onslaughts. He would seize the leg whenever he could get hold of it. I have seen him time and again place both hands on each side of the 'sore,' apparently gently pressing down the edges, just as a little kitten in nursing would keep up a pressure on the milk-ducts, and simultaneously suck with all his might."

Blindness and its Causes.—According to the last census returns there were, in the United Kingdom of Great Britain and Ireland, 31,159 blind persons, or one in 1,015 of the population. The proportions in different parts of the kingdom vary greatly, from one in 635 in Cornwall to one in 1,367 in Durham; the proportion being higher in agricultural than in urban districts. It is gratifying to learn that though the actual number of the blind increases, their proportion to the seeing population diminishes—a change which is probably due partly to the improvements in ophthalmic surgery, partly to the greater attention paid to the laws of hygiene. But that there is still room for much improvement in the latter respect is only too apparent from the imperfect returns of the *causes of blindness* made by the directors of a few schools for the blind. Thus the report of the York School shows that out of 82 pupils 36 lost their sight from purulent ophthalmia. And similar results are observed in countries on the European Continent. For instance, according to Marjolin, out of 208 pupils in the Paris Institution for the Blind, 80 became blind from this disease, and 18 from small-pox; so that one half lost their sight from preventable causes. In the institutions of Germany the loss of sight from purulent ophthalmia is stated to be about 30 per cent.

The impairment of eyesight by habitual protracted reading has been made a special subject of study by M. Javel, a French physician, who also proposes a method of reducing to a minimum the damage so caused. In the first place, reading requires an absolutely permanent application of eyesight, resulting in a permanent tension of the organ. Secondly, books are printed in black

on a white ground; the eye is thus in presence of the most absolute contrast which can be imagined. The third peculiarity lies in the arrangement of the characters in horizontal lines, over which we run our eyes. If, during reading, we maintain a perfect immobility of the book and the head, the printed lines are applied successively to the same part of the retina, while the interspaces, more bright, also affect certain regions of the retina, always the same: the result is fatigue. Last and most important of all, in M. Javel's estimation, is the continual variation of the distance of the eye from the book. The accommodation of the eye to the page undergoes a distinct variation in proportion as the eye passes from the beginning to the end of each line; and this variation is all the greater in proportion to the nearness of the book to the eye, and the length of the line. In order to avoid these injurious effects, M. Javel advises frequent intermissions during reading. To reduce the contrast between the white of the paper and the black of the characters, M. Javel recommends the adoption of a slightly yellow tint of paper. His third suggestion is to give preference to small volumes which can be held in the hand, which obviates the necessity of the book being kept fixed in one place, and lessens the fatigue resulting from accidental images. Lastly, M. Javel advises the avoidance of too long lines, and therefore he prefers small volumes, and for the same reason those journals which are printed in narrow columns. Of course, every one knows that it is exceedingly injurious to read with insufficient light, or to use too small print.

An Insect Ragman.—A correspondent of "Hardwicke's Science Gossip" tells of a very curious discovery he made last summer at Bellosguardo near Florence, viz., a veritable insect ragman. Having noticed what he at first took to be a little nest of spiders' eggs blown along a window-sill, he was led to examine it more closely, and found it to be a rather untidy, fluffy ball, about the size of a large pea; further, that it was moving along of its own accord, stopping now and then for a second, and again resuming its journey. It was soon discovered that the ball of fluff was borne on the back of a little insect somewhat resembling the larva of the *dermestes*, and that the mass was composed of cobweb held on the creature's back by being twisted about in and out among the long hairs on the upper surface of the body. The insect was about one quarter of an inch in length, and bore on its head a pair of forceps about the size of those borne by the common earwig, but its purpose was very different, "for to my amazement," says the author, "I noticed that, each time the creature paused, it was to pick up, with these forceps, some dead ant or portion of a dead insect; and these fragments were picked up so deftly, and in so droll a way did the creature turn its head round and carefully arrange his treasure on his pack, that I was forcibly reminded of the chiffonniers in France and Italy, with their hook and their basket, and of the 'ole clo'' and his pack in England. . . . For more than two days I kept it in a small glass-lidded box, supplied it with 'ole clo',' and watched it constantly collecting and packing; but I never saw it feed, and one morning I found that a large ant I had supposed to be dead had attacked and eaten the creature, scattering the fluffy pack and its contents all over the box." Some weeks after this the author received a note from a friend at Vevey, who from the description recognized the "chiffonnier," two of which, she says, "came toward me, on the table in the garden where I was seated reading, *collecting* and *packing* as you have described." From a friend at Bellosguardo he also, on his return to England, received an account of one she had found, and of which she thus writes: "I had half a mind to send you one of those scavenger or 'ole clo'' insects; but could not arrange anything that would insure its arriving alive. The pack on his back is much less choice than the others, consisting of parts of the bodies of dead flies, spiders' cobwebs, etc., while he himself is much smaller. I feel quite sure it is his food he collects, because the first night I put him under a tumbler he ate the wings of his fly, the only ornamental article in his collection. He is exceedingly fond of sugar—has eaten, I am sure, twice his weight—and has just added two small dead ants to his load, under which he staggers visibly. His pack is held on by long, projecting hairs, and likewise secured and strengthened by cobwebs."

NOTES.

The Royal Astronomical Society of London has awarded a gold medal to Professor Asaph Hall for "his discovery and observations of the satellites of Mars."

Heinrich Geissler, inventor of sundry ingenious physical apparatus—the Geissler tubes, the vaporimeter, etc.—died January 24th, at Bonn, aged sixty-five years.

Professor J. Lawrence Smith finds that the native irons of Greenland are mutually similar, and that they differ from the meteoric irons. He thinks it probable that the native iron may have been brought up from below, like the native alloy of platinum and iron.

Professor Daniel Wilson, of Toronto, is of the opinion that in the French Canadians there is a liberal infusion of Indian blood. In the neighborhood of Quebec, in the Ottawa Valley, and to a great extent about Montreal, there is, he believes, hardly a family descended from the original settlers who have not some traces of Indian blood. At Ottawa, where the French-Canadian element is strong, the traces of Indian blood are discernible in nearly every individual belonging to that race.

A diligent observer of the ways of animals, Mr. Sidney Buxton, says that dogs and horses are, as far as he knows, the only animals sensitive to ridicule, while cats and birds are wholly unaware that they are being laughed at. Certainly dogs, and probably horses, know the difference between being laughed at in derision, as we laugh at a fool, and being laughed at in admiration, as we laugh at a good comic actor—and enjoy the latter as much as they resent the former. Some parrots, however, seem to understand and enjoy the practice of making fun of their human acquaintances.

In Switzerland, the men conscripted into the army have to undergo an examination in reading, writing, arithmetic, history, and the geography and political Constitution of Switzerland. At the last examination not a single unlettered conscript was found in thirteen cantons, and the proportion of illiterates exceeded two per cent. in only three cantons, viz., Appenzell, Fribourg, and Valais. In these cantons the illiterates did not exceed four per cent. of the total number of conscripts.

The London "Lancet" denominates the movement for the cremation of dead bodies a "craze," now that steps have been actually taken to dispose of bodies in that way in England. It questions whether time will ever so completely obliterate the "sense of decency" in the people of England that the notion of burning the dead will be tolerated. To the Lancet, the idea of cremation is "revolting."

In London the seven weeks ending January 18th was a period of very low temperature, and the Registrar-General, in his reports, institutes a comparison between the mortality of those seven weeks and the seven weeks immediately preceding them. The result shows that the average weekly number of deaths in the cold period exceeded by 481 the average number in the period of moderate temperature, the annual rates of mortality being equal to 26·8 and 19·8 per 1,000 respectively. Among persons under twenty years of age the increased mortality due to cold did not exceed 2·8 per 1,000 living, and the excess between twenty and forty was only 1·3 per 1,000. Between forty and sixty years the excess was 8·7 per 1,000, between sixty and eighty it was 54·4, and among persons over eighty years of age the excess was equal to 173·0 per 1,000 per year.

A correspondent of the Hiogo (Japan) "News" writes to that journal that the sect of the *Nishi Honganzi* are erecting several large buildings in the foreign styles near their temples, to be used for school purposes. In addition to the usual Japanese course, English will be taught. The school is intended for educating priests of the sect named, and a select few, when their education is finished, will be sent as apostles and evangelists to Europe and America, to win to the true faith the inhabitants of those benighted regions.

Pteratomus Putnamii, or "Putnam's winged atom," is the very appropriate name given by Professor Packard to a creature first described by him, and which is probably the smallest of all known insects. An individual of this species was captured last summer by Mr. J. D. Cox, who gives a full description of it in the "American Naturalist." Its body is twelve thousandths of an inch in length, the antennæ twenty thousandths. It is probably an egg-parasite of the leaf-cutter bee.

A new invention of great interest is announced in "Nature," viz., *a real telegraph*, an instrument with the aid of which one literally writes at a distance. A writer, say at London, moves his pen, and simultaneously at some other point, Brighton for instance, another pen is moved in precisely the same curves and motions. The inventor is E. A. Cowper.

An International Exhibition, or World's Fair, will be held next August in Sydney, Australia. This announcement is in itself an evidence of the marvelous development of wealth, industry, and refinement among the antipodes.

INDEX.

Books noticed: PAGE

END OF VOL. XIV.

10435